SEWRPC Community Assistance Planning Report Number 60 (3rd Edition)

A LAKE MANAGEMENT PLAN FOR GENEVA LAKE
WALWORTH COUNTY, WISCONSIN

Chapter 1

PLAN PURPOSE AND GOALS

Geneva Lake ("Lake") lies within U.S. Public Land Survey Township 2 North, Range 17 East, Town of Geneva; Township 1 North, Range 17 East, Town of Linn; and Township 1 North, Range 16 East, Town of Walworth, all in Walworth County, Wisconsin (see Map 1.1). Geneva Lake, together with its associated watershed and wetlands and woodlands, is an important, high-quality natural resource and is a substantial asset to the local and regional community. For this reason, preserving and enhancing the Lake's health is an issue of considerable interest to resource managers, Lake residents, Lake users, businesses, local municipalities, County, and others who benefit from the Lake's recreational, ecological, and aesthetic value.

1.1 PLAN PURPOSE AND OVERVIEW

The health of a lake or stream is usually a direct reflection of land use and management within the lake's watershed (the land surrounding a lake that slopes toward the lake or a tributary stream, and that contributes runoff to the lake) as well as in-lake activities. In the face of human-induced change, active intervention is often necessary to stabilize, maintain, or enhance resource conditions. This management plan focuses on what can be done to protect critical resources from human-induced deterioration and prevent future water pollution or resource degradation. This management plan is the third lake management plan developed by the Southeastern Wisconsin Regional Planning Commission (the "Commission") for Geneva Lake, the first having been completed in 1985 and the second in 2008.[1,2] This plan complements other existing programs and ongoing management actions in the Geneva Lake watershed and represents the continuing commitments of government agencies, municipalities, and citizens to diligent land use planning and natural resource protection. This plan recommends appropriate

[1] *SEWRPC Community Assistance Planning Report No. 60, A Water Quality Management Plan for Geneva Lake, Walworth County, Wisconsin, October 1985.*
[2] *SEWRPC Community Assistance Planning Report No. 60 (2nd Edition), A Water Quality Management Plan for Geneva Lake, Walworth County, Wisconsin, May 2008.*

and feasible watershed management measures to help enhance and preserve the water quality, aesthetics, and ecological integrity of the Lake and its tributaries and provide the public with opportunities for safe and enjoyable recreation within the Lake and its watershed. This document's primary purpose is to review previous lake management plan implementation achievements and analyze available data and provide an updated management framework with specific recommendations. Such information enables organizations to take appropriate measures to protect the health and use value of the Lake.

This plan is divided into three chapters. Chapter One briefly outlines the plan's purpose, summarizes basic Lake characteristics and assets, and describes general goals and objectives. Chapter Two presents and interprets information needed to understand Lake conditions and the factors that could imperil Lake health. Finally, Chapter Three discusses approaches to protect and enhance the Lake and its watershed. Chapter Three recommendations aim to enhance Geneva Lake's native plant community, ecology, and water quality, while allowing Lake users and watershed residents opportunities for safe and enjoyable recreation within the Lake and the Lake's watershed.

This management plan provides practical guidance for maintaining or enhancing the water quality of Geneva Lake and for managing lands that drain directly and indirectly to the Lake and its tributary streams. The plan is developed to assist units of government, nongovernmental organizations, businesses, and citizens in developing strategies benefiting the natural assets of Geneva Lake and protecting sensitive and other high-value habitats within its watershed. By applying the strategies outlined in this plan, the natural environment can be enriched and preserved. In addition, carefully planned urban development can preserve ecological benefits that directly benefit human habitation. For example, planning can create and maintain desirable aesthetics, groundwater recharge areas, and wildlife corridors, as well as address issues related to existing and future development (e.g., stormwater runoff pollution) all of which benefit Geneva Lake's ecology, watershed residents and businesses, and visitors.

This planning program was funded in part by a Chapter NR 193 Lake Management Planning grant awarded to the Geneva Lake Conservancy (the "GLC"). Examples of major grant program deliverables include the following items:

- Maps delineating the watershed and defining characteristics such as groundwater recharge potential, buffers, and existing/planned land use

- Assess conditions and trends for the Lake's water quality, aquatic plant community, and fisheries depending upon available data
- Field investigations of select Lake tributaries
- Surveying the opinions of riparian and watershed residents on Lake issues
- Hosting two focus group meetings to discuss water quality and recreational use issues
- Completing an updated comprehensive management plan for the Lake

1.2 CHARACTERISTICS AND ASSETS OF GENEVA LAKE AND ITS WATERSHED

Geneva Lake is one of Wisconsin's largest (5,262 acres) and deepest (140-foot maximum depth) lakes. The Lake is renowned for good water quality and hosts a remarkably diverse array of high-quality recreational opportunities. For this reason, Geneva Lake is one of Wisconsin's premier tourist destinations. Located in Walworth County, it is within easy driving distance of several large metropolitan areas, offers excellent public access and use opportunities, is heavily used by residents and visitors, and is an invaluable resource to local communities. Despite being set in a highly developed landscape close to major metropolitan areas, the Lake maintains good water quality and overall ecological health.

For its size, Geneva Lake has a very small watershed (less than 30 square miles). Nevertheless, human actions occurring on and near the Lake and within its watershed can negatively affect Lake health. As a result of this concern and the Lake's long-term popularity, Geneva Lake has been the subject of many studies for over a century. These studies include those completed by federal and state agencies, Walworth County, local municipalities, various universities and schools, an array of Lake-focused groups, and volunteers. Furthermore, the Commission has completed numerous studies over the past decades providing valuable insight into Lake-related issues. Most salient to ongoing lake management are a 1985 water quality study and the 2008 lake management plan.[3,4]

The Geneva Lake community has a long history of efforts by the residents to protect and improve the Lake's utility. The very first lake organization in the State of Wisconsin was formed around Geneva Lake in 1898. Subsequently, other lake organizations were formed at Geneva Lake to manage lake levels and water quality as evidenced by the formation of such groups as the Geneva Lake Association in 1935, the Geneva Lake

[3] *SEWRPC Community Assistance Report Number 60,* A Water Quality Management Plan for Geneva Lake, Walworth County, Wisconsin*, 1985*.
[4] *SEWRPC Community Assistance Report Number 60, 2nd Edition, op. cit.*

Level Corporation, the Geneva Lake Environmental Agency (GLEA) in 1971, and the Geneva Lake Conservancy in 1981.

1.3 LAKE MANAGEMENT GOALS AND SCOPE

In January 2023, the GLC along with the Wisconsin Department of Natural Resources, Southeastern Wisconsin Regional Planning Commission, Walworth County, Geneva Lake Environmental Agency (GLEA), Geneva Lake Association (GLA), and the Water Alliance for Preserving Geneva Lake hosted a "Kickoff Meeting" in preparation for updating the Lake's management plan. The GLC along with all the partners mentioned above also collaboratively developed and sent out a "Lake User Survey" in 2023. Both the Kickoff Meeting and the Lake User Survey gave lake residents, stakeholder groups, and the general public the opportunity to voice their goals and concerns and are listed below.

- Minimize degradation to Geneva Lake and its tributaries to maintain "High-Quality Water" Lake status[5]
- Identify opportunities to improve the quality of the land and water (including groundwater) resources within the watershed by reducing both nonpoint agricultural and urban runoff
- Balance management for recreational use of the Lake with the ecological health of the Lake
- Mitigate the impacts of stream bank erosion and pollutant loading from tributaries into the Lake
- Promote strategies to increase the Lake's resistance to the impact of climate change
- Promote and maintain coordination and collaboration among residents, farmers, landowners, businesses, community associations, as well as governmental and non-governmental organizations

The tasks outlined below were developed in collaboration with the GLC and aim to best address the concerns brought to the Commission by the GLC and its partners. These tasks form the basis of this plan update and aim to provide strategies and framework to work towards and achieve not only the goals outlined above but also address future concerns of stakeholder groups on Geneva Lake.

- Task 1: Update in-lake datasets and evaluate meaning and implications
    - Subtask 1.1: Re-evaluate Geneva Lake's aquatic plant community
    - Subtask 1.2: Re-evaluate Lake water quality data

[5] Geneva Lake was designated as a "High-Quality Water" by WDNR in 2022.

- Subtask 1.3: Examine sediment deposition at the mouths of three prominent Lake tributaries
    - Subtask 1.4: Evaluate boat traffic characteristics
    - Subtask 1.5: Evaluate Bigfoot Creek water quality concerns
    - Subtask 1.6: Review impact of past lake management efforts
- Task 2: Quantify stakeholder perceptions, needs, desires, and aspirations and foster cooperation
    - Subtask 2.1: Social survey of lake and watershed residents
    - Subtask 2.2: Stakeholder education/outreach
    - Subtask 2.3: Enhance stakeholder cooperation and collaboration
- Task 3: Inventory watershed conditions and evaluate their influence on lake health
    - Subtask 3.1 Delineate and characterize the Lake's watershed
    - Subtask 3.2: Evaluate select tributaries
    - Subtask 3.3: Windwood Creek watershed demonstration project
    - Subtask 3.4: Examine Lake-tributary stormwater infrastructure

Continued collaboration along with improved communication and sharing of resources amongst communities, organizations, and lake residents to achieve the desired water quality and recreational goals for Geneva Lake as identified in this plan will be critical for its future management and protection.

A LAKE PROTECTION PLAN

FOR GENEVA LAKE, WALWORH COUNTY, WISCONSIN

3rd EDITION

Chapter 2

INVENTORY FINDINGS AND RELEVANCE TO LAKE MANAGEMENT

2.1 INTRODUCTION

As a part of the planning process, issues of most concern were identified through various means, including an initial informational kick-off meeting, lake user survey, recreational use surveys, targeted stakeholder meetings with members of the Lake community as well as numerous meetings with the Geneva Lake Conservancy (GLC), Geneva Lake Environmental Agency (GLEA), Geneva Lake Association (GLA), the Water Alliance for Preserving Geneva Lake, and other project partners including Wisconsin Department of Natural Resources (WDNR), Walworth County staff and local municipalities. These issues and inventory findings are the basis for the topics addressed in this management plan. This chapter provides information and interpretations that will 1) help answer questions posed by the GLC, GLEA, GLA, and other partners and concerned community members and 2) inform the development of concepts that help safeguard long-term Lake health and human-based value. Additionally, Chapter Two presents data and interpretations relevant to understanding the dynamics and overall health of Geneva Lake. This includes study of both in-Lake processes as well as the land areas providing runoff to the Lake ("watershed"). Resultant data help examine how the Lake is influenced by, and react to, their surrounding environment. With this background, the overall health of the Lake, situations that concern lake users, and conditions that could contribute to water quality and/or quantity problems are evaluated. Concepts that help the GLC, GLEA, GLA, and their project partners address specific concerns are subsequently presented in Chapter Three.

2.2 LAKE AND WATERSHED CHARACTERISTICS

The condition and overall health of a waterbody is directly related to the natural and human-induced characteristics and natural features within the area draining to the waterbody, an area known as the watershed. This assemblage of unique natural features and processes can be collectively referred to as physiography. This section describes the Lake and watershed physiography including the shape and arrangement of landscape features, the composition and arrangement of soil and rock, tributary streams and Lake basin shapes, how water moves through the area, and how humans influence the landscape.

The landscape characteristics and land use practices around a lake control a lake's water quality and overall character. Therefore, it is important to characterize the area draining to a lake—its watershed—to understand natural resource elements, human manipulation, potential pollution sources and risks to the lake's water quality. Both natural and human-induced characteristics of areas draining to waterbodies have direct impacts on their overall health and condition. This section very briefly describes these influential characteristics, including the shape and arrangement of landscape features. For more in depth descriptions of those features please refer to the 2008 second edition of the Lake's management plan.[1]

Watershed Extent

The watershed of Geneva Lake encompasses over 18,406 acres (including the Lake itself) and includes portions of the Towns of Bloomfield, Delavan, Geneva, Linn and Walworth; the City of Lake Geneva; and the Villages of Fontana-on-Geneva Lake, Walworth, and Williams Bay, as shown on Map 2.1. With contributions from the University of Wisconsin – Whitewater, this watershed extent was modified from previous editions of this management plan based on field surveys and refined topographic data. The most significant changes are along the south central extent in the Town of Linn and the northwestern portion in the Village of Williams Bay and in the Towns of Delavan and Walworth.

The Lake itself is located in the City of Lake Geneva, the Villages of Fontana-on-Geneva Lake and Williams Bay, and Towns of Linn and Walworth. At 5,262 acres, Geneva Lake is the largest lake in Walworth County and southeastern Wisconsin and the 16th-largest lake in Wisconsin. With a maximum depth of 140 feet, the

[1]*SEWRPC Community Assistance Planning Report No. 60, 2nd Edition,* A Lake Management Plan for Geneva Lake, Walworth County, Wisconsin, *May 2008.*

Lake is also the deepest lake in Walworth County and southeastern Wisconsin as well as the fifth deepest in the state (see Map 2.2).

The watershed/lake area ratio contrasts the size of a lake to its contributing watershed. Lakes with higher ratios are typically considered more vulnerable to human influence and prone to water quality problems. However, the way the watershed is used can greatly influence the amount of pollutants carried to the Lake. As a rule of thumb, lakes with a watershed/lake ratio greater than 10:1 often experience some water quality issues. With a contributing area of 13,144 acres and a surface area of 5,262 acres, Geneva Lake's watershed/lake area ratio is approximately 2.5:1 while the typical Wisconsin inland lake has a watershed/lake area ratio of 7:1.[2] This finding suggests that the Lake is considerably less vulnerable to human influence and land use in its watershed than a typical Wisconsin lake.

Climate and Weather

Weather and climate describe the same parameters, including, but not limited to atmospheric temperature, precipitation, humidity, wind speed, and cloud cover. However, weather and climate are not synonymous. The term "weather" generally describes conditions over short periods of time, such as minutes, hours, days, or weeks. In contrast, the term "climate" describes long-term weather averages, and typically considers time periods of decades or longer. Long periods of weather data are necessary to describe climate and allow changing climate to be noted. Weather conditions have been recorded in Southeastern Wisconsin for well over 100 years. In Walworth County, air temperature, precipitation, snowfall, and snow depth data have been collected since 1893. Available data throughout the state indicate that Wisconsin's climate is changing. [3,4] Additional historical data analysis demonstrates that water resources are intimately linked to local and regional climate conditions. Long-term records of lake water levels, lake-ice duration, groundwater levels, and stream baseflow are correlated with long-term trends in atmospheric temperature and precipitation.[5]

[2] *R.A. Lillie and J.W. Mason,* Limnological Characteristics of Wisconsin Lakes*, Wisconsin Department of Natural Resources Bulletin No. 138, 1983.*

[3] *Dataset available through the National Centers for Environmental Information (NCEI) Climate Data Online (CDO) Search*

[4] *C.J. Kucharik, S. P. Serbin, S. Vavrus, E.J. Hopkins, and M.M. Motew, "Patterns of Climate Change Across Wisconsin from 1950 to 2006," Physical Geography, 31(1): 1-28, 2010.*

[5] *Wisconsin Initiative on Climate Change Impacts (WICCI), Wisconsin's Changing Climate: Impacts and Adaptation, Nelson Institute for Environmental Studies, University of Wisconsin-Madison, and Wisconsin Department of Natural Resources, February 2011.*

The Wisconsin Initiative on Climate Change Impacts (WICCI) concludes that projected future climate change will affect Wisconsin's water resource quantity and quality.[6] However, WICCI also found clear evidence, from analysis of past and probable future climate trends, that various geographic regions of Wisconsin respond differently to climate change (see Figure 2.1). These differences can reflect local variations in land use, soil type, and/or groundwater characteristics, all of which influence the amount of precipitation that exits an area as runoff, infiltration, or evapotranspiration. This illustrates the importance of including existing and future land use conditions as part of the watershed protection plan strategy.

Ongoing and future climate change may alter the distribution and intensity of rainfall, the form of precipitation (e.g., rain or snow), and runoff volume, all of which affect water's movement through the water cycle. As shown in Figure 2.2, water entering the landscape arrives as precipitation. This precipitation can fall directly on surface waters, run off the land surface into waterbodies, or percolate into the soil to recharge groundwater that later re-emerges as spring, seeps, or human well discharge (e.g., from private water supply wells and/or onsite wastewater treatment systems) and contribute to surface waters.

Climate change may expose the vulnerabilities of water supplies within a given natural system or human community, and this vulnerability is commonly proportional to how significantly humans have altered the hydrologic cycle. Water supply vulnerability is often most evident during protracted dry weather, while flooding and infrastructure failure are most evident during extremely wet weather. Even independent of climate change, when elements of the hydrologic cycle change, the surface- groundwater interactions may be affected. For example, intense groundwater pumping and consumptive use can reduce or completely deplete flow in local streams (see "Groundwater Resources" later in this section).

The WICCI Water Resources Working Group (WRWG) incorporated WICCI's 1980-2055 temperature, precipitation (including occurrence of events), and changes in snowfall projection to evaluate potential hydrolytic processes and resource impacts.[7] This team of experts identified and prioritized the most serious

[6] *Wisconsin Initiative on Climate Change Impacts, February 2011, op. cit.*

[7] *The Water Resources Working Group (WRWG) included 25 members representing the Federal government, State government, the University of Wisconsin System, the Great Lakes Indian Fish and Wildlife Commission, and the Wisconsin Wetlands Association, Members were considered experts in the fields of aquatic biology, hydrology, hydrogeology, limnology, engineering, and wetland ecology in Wisconsin. Over the course of a year, the group convened to discuss current*

potential water resource problems related to anticipated climate change and proposed strategic adaption strategies to address those impacts across the State of Wisconsin (see below). The WRWG offers the following guidance to help local communities develop adaptation strategies.[8]

- ***Minimize threats to public health and safety by anticipating and managing for extreme events-floods and droughts****. We cannot know when and where the next flooding event will occur or be able to forecast drought conditions beyond a few months, be we do know that these extreme events may become more frequent in Wisconsin in the face of climate change. More effective planning and preparing for extreme events is an adaptation policy.*
- ***Increase resiliency to aquatic ecosystems to buffer the impacts of future climate changes by restoring or simulating natural processes, ensuring adequate habitat availability, and limiting human impacts on resources****. A more extreme and variable climate (both in temperature and precipitation) may mean a shift in how we manage aquatic ecosystems. We need to try to adapt to the changes rather than try to resist them. Examples include managing water levels to mimic pre-development conditions at damns and other water level structures, limiting groundwater and surface water withdrawals, restoring or reconnecting floodplains and wetlands, and maintaining or providing corridors for fish and other aquatic organisms.*
- ***Stabilize future variations in water quality and availability by managing water as an integrated resource, keeping water "local" and supporting sustainable and efficient water use****. Many of our water management decisions are made under separate rules, statutory authorities, administrative frameworks, and even different government entities. This can lead to conflicting and inconsistent outcomes. In the face of climate change, the more we can do to integrate these decisions at the appropriate geographic scale, the better adapted and ready for change we will be. In addition, treating our water as a finite resource and knowing that supply will not always match demand will allow for more sustainable water use in the future.*
- ***Maintain, improve, or restore water quality under a changing climate regime by promoting actions to reduce nutrient and sediment loading.*** *Water quality initiatives need to be redoubled*

climate-related water resources research, potential climate change impacts, possible adaptation strategies, and future research and monitoring needs across the entire State of Wisconsin. For more details on climate change, impacts, adaptation, and resources visit www.wicci.wisc.edu/water-resources-working-group.php.

[8] *Wisconsin Initiative on Climate Change Impacts, February 2011, op. cit.*

under a changing climate to minimize worst-case scenarios such as fish kills, harmful blue-green algae blooms, severe soil erosion and to prevent exacerbating existing problems.

Climate projections developed using United States Geographical Survey's (USGS) National Climate Change Viewer show significant probability of increasing mean annual temperatures in the Upper Fox River watershed, in which Geneva Lake lies. There is less model agreement regarding annual precipitation.[9] Most additional precipitation falls in fall and winter, and wetter than normal spring weather is often a harbinger of greater than normal annual precipitation. The published National Oceanic and Atmospheric Administration (NOAA) for the 1991-2020 and the 2006-2020 climate normal for the weather station at the Delavan wastewater treatment facility are presented in Table 2.1. As indicated by the difference in these climate normals, the average temperature increased by nearly 1.4 degrees Fahrenheit with nearly 3 additional inches of annual precipitation in the past 15 years. Commission staff have also compiled precipitation records from weather stations in Beloit and Union Grove illustrating the long-term increases in total annual precipitation and the increasing frequency of one-inch rainfall events (see Figures 2.3 and 2.4). These increased rainfall events have been observed to increase mass loadings and streambed and bank erosion among various tributaries discharging to Geneva Lake by concerned local residents, GLC, and Walworth County staff which prompted a targeted tributary study in 2020 (see "Tributary Streams" subsection below for more details).

Over the past three decades, fall and winter have been warming faster than spring and summer. These warming winter temperatures have strongly influenced the formation and duration of ice cover on Geneva Lake. Records of ice thaw from Geneva Lake indicate that the length of ice cover is decreasing and thaw is occurring earlier in the year.[10] Between 1862 and 1872, ice-on occurred on average around December 21st while ice-on has occurred on average around January 20th between 2008 and 2018.[11] The Lake completely froze over each winter between 1862 and 1996, but in 1997 and in several subsequent years the Lake has not attained complete ice coverage.[12] The shorter duration of ice cover, lack of complete ice coverage, and

[9] *As illustrated by the USGS National Climate Change Viewer for the Upper Fox River watershed. For more information, see https://apps.usgs.gov/nccv/loca2/nccv2_loca2_watersheds.html*

[10] *Information on changes in lake ice is provided at https://www.epa.gov/climate-indicators/climate-change-indicators-lake-ice.*

[11] *Ibid.*

[12] *https://lakegenevanews.net/news/local/climate-change-cited-as-geneva-lake-stays-unfrozen-again/article_db287d67-4e17-574b-9c9a-e32ec767ac18.html*

warming winter temperatures has complicated some winter activities on the Lake, such as ice fishing, the Lake Geneva Winterfest, and the Geneva Lake Ice Castles.[13,14] Loss of ice cover can also impact the lake's ecology, with greater susceptibility to southern invasive species, higher risks of algal blooms, greater stress for cold and coolwater fish species, and disruption of aquatic organism life cycles.[15]

Changes in patterns of temperature, ice cover, and precipitation can impact soil runoff, stormwater infrastructure, tributary erosion and sediment loading, shoreline erosion, water quality, dam operation, and the growth of aquatic plants. These insights should be integrated into water resource management, lake management strategies, and water infrastructure design. Recommended practices and strategies for adapting to climate change will be discussed in Chapter 3.

Topography

About 280 feet of topographic relief is found in the Lake's watershed, with land surface elevations ranging from roughly 864 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD 29) along the Lake's shoreline to elevations of almost 1,144 feet above NGVD 29 along the crests of prominent hills and ridges in the western portions of the Lake's watershed (see Map 2.3). Specified subbasins and their maximum elevations are shown in Map 2.4 and Table 2.2.

Areas of significant topographic relief are prone to long and/or steep slopes which are more likely to experience erosion, and less likely to allow water to permeate through the soil. Generally, less permeable soils and steeper slopes generate more erosive potential and a greater ability to carry pollutants and sediments to receiving waters. This situation can be exacerbated if slopes are unvegetated, paved, or relatively impermeable, affecting both the type and amount of pollutants entering surface waters. As mentioned above, this situation can also be exacerbated by increased precipitation, especially high intensity

[13]*https://spectrumnews1.com/wi/milwaukee/news/2024/02/02/lake-geneva-winter-fest-warm-temperatures-snow-sculpture-ice-sculpture-*

[14] *https://www.jsonline.com/story/life/2024/10/17/ice-castles-wont-return-to-lake-geneva-wisconsin-this-winter-2024-2025/75716099007/*

[15] *M.R. Magee, C.L. Hein, J.R. Walsh, et al., "Scientific Advances and Adaptation Strategies for Wisconsin Lakes Facing Climate Change,"* Lake and Reservoir Management 35 (4): 364-381, 2019. https://www.fs.usda.gov/nrs/pubs/jrnl/2019/nrs_2019_magee_001.pdf

precipitation events, both of which are increasing within this watershed (see Figure 2.5 for example of head cutting erosion that can occur due to increased stormwater discharge)

Slopes in the Geneva Lake watershed range from essentially flat to greater than 20 percent. As shown on Map 2.5, most areas in the Geneva Lake watershed are relatively level, with 44 percent of the watershed underlain by land surfaces sloping at 2 percent or less, and 70 percent sloping at 6 percent or less (see Table 2.3). The lowest slopes are generally found in the northwest portion of the watershed, but some of the flattest areas in the watershed are directly adjacent to some of its steepest slopes. An example is found in the southwest portion of the watershed in the Village of Fontana-on-Geneva-Lake. Steeply sloping lands (lands with slopes greater than 20 percent) occupy about 2 percent of the Lake's topographical watershed. The stark contrast in the erratic, steeply sloping relic landforms to the flatter areas are related to historic glacial activity. Topographically flat areas near Geneva Lake likely represent extinct portions of the Lake beyond its modern shoreline.

Soils

Soil is the uppermost layer of terrestrial sediment and results from a combination of weathering and biological activity. The type of soil underlying an area is influenced by several factors, including, landscape position and slope, parent material, hydrology, and the types of plants and animals present. Soil types affect the rate and amount of stormwater runoff, and, as such, are contributing factors to overall lake water quality. The Geneva Lake watershed has a diverse array of soils, with the majority belonging to the Miami Association.[16,17] Miami Association soils are generally well-drained, with subsoils consisting of silty clay loam and clay loam. These soils were formed under hardwood forest cover from loamy or sandy glacial till, with a modest veneer of loess (wind-deposited silt). Other soil types in the Geneva Lake watershed include Casco-Rodman and Houghton-Palms Associations.

Casco-Rodman soils are found on prominent ridges and hills in the west of the Lake's watershed, as they are commonly found in areas of irregular topography and great topographic relief. Casco-Rodman soils are well to excessively-well drained, making them prone to drought, and are generally coarse-grained with little

[16] *For a complete listing of soil types, see page 6 of SEWRPC Community Assistance Planning Report No. 60, 2nd Edition,* A Lake Management Plan for Geneva Lake, Walworth County, Wisconsin, *May 2008.*

[17] *Haszel, Orville L.,* Soil Survey of Walworth County, Wisconsin*, United States Department of Agriculture, 1971.*

topsoil. Subsoils include clay loam, silty clay loam, or gravely clay loam, with parent materials typically consisting of a thin layer of loess resting upon stratified sand and gravel glacial outwash or stream terrace deposits. Houghton-Palms Association soils are found in the eastern portion of the watershed, as well near the Villages of Fontana-on-Geneva-Lake and Williams Bay. Houghton-Palms Association soils are poorly drained and highly organic, usually located in depressions and on bottom lands. These soils developed in decomposing plant material remains within topographic depressions and wetlands, such as those in the level southeastern portions of the watershed.

In addition to soil type, the Commission completed a detailed soil survey of the Geneva Lake area that identified the location of hydric and non-hydric soils and contained applications for planning, engineering, and agriculture of the area.[18] Hydric soils are formed when soils are saturated for extended periods of time, indicating groundwater near the land surface, ponding, or extended flooding, and are commonly associated with wetland areas. Approximately 7 percent of the Geneva Lake watershed is underlain by soils exhibiting hydric/predominantly hydric characteristics. Most of these areas are in the Villages of Williams Bay and Fontana-on-Geneva-Lake, as well as near Big Foot Beach State Park (Map 2.6). Many hydric soils were likely drained in the past for human use and development. However, hydric soil areas are often sites of physical and biological processes that can both protect and sustain a lake's water quality, therefore warranting protection.

In addition to hydric ratings, soils can be categorized into hydrologic soil groups to indicate the amount of runoff from bare soil following prolonged wetting.[19] Highly permeable soils, such as sandy and/or gravelly soils, generally generate less runoff than low permeability soils, such as soils with over 40 percent clay. During precipitation events, highly permeable soils quickly move water to lower soil layers. In contrast, low permeability soils rapidly become saturated, causing water to move over land surfaces to topographically lower areas as runoff. Soils are placed in four broad groups (A, B, C, and D) indicating the amount of runoff that can be expected from the soil, with A as the lowest runoff potential and D as the greatest runoff potential. Around 86 percent of the land in the Geneva Lake tributary area is covered by B groups with moderate runoff potential, and around 10 percent covered by C and D groups which have moderately high to high runoff potential.

[18] *SEWRPC Planning Report No. 8,* Soils of Southeastern Wisconsin*, June 1966.*

[19] *SEWRPC Planning Guide No. 6,* Soils Development Guide*, 1969.*

Water Resources

General Concepts and Management Principles

All water found in Wisconsin's waterbodies and aquifers ultimately originated as precipitation. Some of the precipitation falling upon the landscape runs downhill and is labelled runoff. Runoff from broad areas coalesces forming visible rivulets and streams. The area feeding runoff to a stream is called the stream's watershed. Some precipitation evaporates or is absorbed by plants and is released into the atmosphere. Precipitation that does not run off and does not evaporate soaks into the ground. This infiltrating water replenishes groundwater supplies. Groundwater ultimately feeds such features as aquifers, springs, seeps, and water supply wells. Waterbody water sources include:

- **Precipitation** falling directly upon the surface of waterbodies can be a significant water source to expansive features such as lakes and wetlands. Precipitation falling directly upon streams and rivers is not typically a significant contributor to a stream or river's total water budget.
- **Surface runoff** (or overland flow) is runoff from precipitation or snowmelt that travels over the land surface to a waterbody. Surface runoff is the primary source of water to most waterbodies during wet weather.
- **Interflow** is lateral movement of water through unsaturated sediment. Interflow delivers precipitation or snowmelt sourced water to streams before it enters groundwater.
- **Hyporheic flow** is stream flow within stream bed materials paralleling the general direction of stream flow. Hyporheic flow commonly persists even when visible stream flow ceases. Hyporheic flow initiates and sustains important geochemical and biological processes that support stream health.
- **Groundwater** is the primary source of water to most waterbodies during dry weather. In some instances, waterbodies lose water to the groundwater flow system. Water infiltrating the land surface replenishes groundwater supplies.

Surface runoff and interflow are important during storm events and their contributions typically are combined into a single term called the direct-runoff component of streamflow. Groundwater is most important for sustaining waterbodies during periods between storms and during dry times of the year and is often a substantial component of the total water delivered to a waterbody over the year.

Geneva Lake

Geneva Lake is a headwater (or drained) lake which, although fed by numerous small tributary streams, depends principally on groundwater and rainfall onto the lake surface for its source of water. Geneva Lake, like all drained lakes, has an outlet, in this case the White River, which is a tributary stream system to the Illinois-Fox River system. Water in this system ultimately drains to the Gulf via the Mississippi River.

Glacial Origins

Geneva Lake lies in the pre-glacial Troy Valley, which originally drained to the southwest. During the later stages of the Wisconsin Glaciation, drainage to the southwest was blocked by the Delavan Glacial Lobe which created the Darien Moraine. This blocking of the original drainage, plus the increased elevation of the north and south slopes, raised the surface elevation of Geneva Lake to 14 feet above the elevation of neighboring Como Lake. The presence of an outwash terrace adjacent to the White River and the present depth of Geneva Lake suggest that an ice block broke off the receding glacier and that only this glacial fragment remained in the lake basin, thus limiting the volume of meltwater available for filling the Lake. Had the main body of the Delavan Lobe remained in the vicinity of the Lake, it is hypothesized that the Lake would have filled to a much higher elevation, and significantly increased lake depth.

Lake Morphometry

With a surface area of 5,262-acres, Geneva Lake is 7.6 miles long and 2.1 miles wide at its widest point. The major axis of the Lake lies in an east-west direction. The Lake a maximum depth of 140 feet and a mean depth of about 61 feet (see Map 2.2).[20] Approximately 11 percent of the lake area is less than 10 feet deep, 45 percent of the Lake has a water depth between 10 and 70 feet, and about 44 percent of the Lake has a water depth of more than 70 feet.[21] The most extensive shallow areas are in the southeastern and northeastern portions of the Lake, where the Lake maintains water depths of less than 20 feet within 2,500 feet of shore. The central and western portions of the Lake have steep bathymetric slopes and can attain

[20] *Wisconsin Department of Natural Resources Publication No, PUB-FH-800 2005, Wisconsin Lakes, 2005.*
[21] *Wisconsin Department of Natural Resources,* Lake Use Report No. FX-1, Lake Geneva, Walworth County, Wisconsin*, 1969.*

depths of up to 90 feet within 300 feet of shore.[22] The Lake has a total volume of approximately 320,948 acre-feet, making it one of the largest lakes by volume in Wisconsin.[23]

Retention time refers to the average length of time needed to replace the lake's entire water volume.[24] In general, lakes with larger watershed/lake area ratios have shorter retention times. Retention time can help determine how quickly transient pollutant loads can be flushed from a lake. For example, if retention times are short, pollutants are flushed out of a lake fairly quickly. In such cases, management efforts can likely focus on pollutant and nutrient loads contributed to the lake from the watershed. In contrast, lakes with long retention times tend to accumulate nutrients and pollutants. These can eventually become concentrated in bottom sediments as opposed to flushed downstream. In this case, in addition to preventing external pollution from entering a lake, it also may be necessary to employ in-lake water quality management efforts to address pollutants not readily flushed from the lake. With a lake-wide retention time averaging 13.9 years, Geneva Lake's flushing rate is significantly slower than Wisconsin statewide averages. This means that the Lake's water quality may change more slowly than occurs for lakes with shorter residence times.

Shoreline development factor compares the length of a lake's shoreline to the perimeter of a perfect circle of identical area. Higher values result when lakes exhibit irregular shapes including such features as bays and peninsulas. Lakes with high shoreline development factors are commonly more biologically productive and have larger proportions of shallow nearshore areas (also referred to as the littoral zone). Extensive littoral zones are conducive to aquatic plant growth which can grow to nuisance levels and which may impede navigation. The littoral zone generally represent the most productive habitat for plant and animal life in a lake. All other things being equal, a lake with a large shoreline development factor would be expected to have more plant and animal life than a lake having a low development factor. Given their longer shoreline lengths per acre of surface water, lakes with high shoreline development factors also commonly

[22] *Areas with steep bathymetric slopes may be more susceptible to shoreline erosion from wave action as there is less friction with the lake bottom to reduce wave energy before hitting the shore.*

[23] *Additional hydrographical and morphometric data of the Lake can be found on page 6 of SEWRPC Community Assistance Planning Report No. 60, 2nd Edition,* A Lake Management Plan for Geneva Lake, Walworth County, Wisconsin, *May 2008.*

[24] *The terms "flushing rate" and "hydraulic residence time" are also commonly used to describe the amount of time runoff takes to replace one lake volume. Flushing rate is the mathematic reciprocal of retention time, while hydraulic residence time is the same value as retention time. Therefore, while residence and retention time are expressed in years and have units of time, flushing rate is typically expressed as the number of times lake water is completely replaced by runoff in one year, and is therefore a rate (units/time).*

have greater numbers of residential lots per surface area of lake and therefore can be subjected to heavy human use pressure. The lake shoreline is 20.2 miles long, with a shoreline development factor of 2.03, indicating that the shoreline is about two times longer than a perfectly circular lake of the same area.

Nearly the entirety of the Lake shoreline is developed, primarily for residential uses but with scattered commercial uses comprised primarily of restaurants and businesses catering to lake users. Thus, the Lake is subject to significant human use pressure with a high number of lots per acre of Lake surface area. As described in the 1985 first edition of the Geneva Lake management plan, the shorelands are comprised predominantly of sand (38.9 percent), rubble (32.5 percent), gravel (27.9 percent), and muck (1.5 percent). The shoreland composition has been a major contributing factor to the historic good transparency of the water in Geneva Lake. Most of the developed shoreland of Geneva Lake has some form of shoreline protection. However, improperly installed and failing shoreline protection structures, and the erosion of natural shorelines on Geneva Lake, could be a limited cause for concern since erosion of shorelines results in the loss of land, damage to shoreline infrastructure, and interference with recreational access and lake use. Such erosion is usually caused by wind-wave activity, ice movement, and motorized boat traffic.

Water Budget

The second edition (2008) of this management plan reported that Geneva Lake primarily receives water through direct precipitation on its surface (50 percent), surface water inflows (43 percent), and groundwater contributions (7 percent).[25] The major outflows from Geneva Lake were reported as surface water outflow over the outlet dam to the White River (60 percent) and evaporation (40 percent). Water budgets constructed in previous studies largely agreed with these results.[26] However, a 2009 study by the Wisconsin Geological and Natural History Survey found that while precipitation is still the major water source (38 percent), groundwater contributions were a more significant source (36 percent) while surface water inflows were less significant (19 percent from surface runoff and 7 percent from baseflow).[27] This study largely agreed with the 2008 management plan in Lake outflows, with discharge to the White River as the major outflow (63 percent), evaporation as the second most important outflow (35 percent), and loss to groundwater as a minor outflow (one percent). This study and the importance of groundwater contributions

[25] *SEWRPC CAPR No. 60 (2nd Edition), 2008,* op. cit.

[26] *See Table 4 in SEWRPC CAPR No. 60 (2nd Edition), 2008,* op. cit. *for more information*.

[27] *M. Gotkowitz, "Groundwater Pumping Near Geneva Lake: Evaluating its Effects on the Lake,"* Wisconsin Geological and Natural History Survey Educational Series 49, *2009*.

to Geneva Lake are discussed in greater detail in the "Groundwater Resources" subsection later in this chapter.

Outlet Dam

The Lake's water levels have been controlled via an outlet dam since the first dam was constructed on the lake in 1836. Dam failures and reconstructions resulted in lake level fluctuations until 1894, when the Geneva Lake Level Corporation (GLLC) was established and the present dam and sluice gates were constructed; a major upgrade of these 1894 structures was completed in 2002 and with additional repairs in 2024.[28] The current structure is a spillway crest with steel outlet gates to allow for additional flow during high water. The WDNR classifies the dam as a large, low-hazard dam with a structural height of 14 feet, a hydraulic height of 8 feet, and a discharge through its principal spillway of 650 cubic feet per second.[29] The GLLC continues to operate the dam and records water levels, which are published on the GLLC website, while the USGS monitors streamflow on the White River downstream of the dam (USGS site 055451345).[30]

Until 2016, the WDNR had not established water level orders for the dam but had set a required minimum discharge of 1.93 cubic feet per second in 1977. During a prolonged drought in 2012, the GLLC petitioned the WDNR to examine this minimum discharge requirement after a complaint of low flow in the White River downstream of the outlet dam. Following assessment of habitat and fish assemblage in the White River by WDNR staff in 2012 and 2013, the WDNR ordered that the minimum discharge from the dam must be 1.0 cubic feet per second at all times with operating levels for Geneva Lake set between 863.71 and 864.31 feet, NAVD 88. The GLLC may petition to the WDNR to draw the Lake down below these levels.[31]

The WDNR approved the Emergency Action Plan for the dam in 2018 and the Inspection, Operation, and Maintenance plan in 2011.[32] The GLLC has noted that the Lake can rise one to two inches with eight to

[28] *For more information about the GLLC, see their website at https://genevalakelevel.com/.*

[29] *WDNR Dam Report No. 85,* Detailed Information for Dam Lake Geneva*, accessed in 2025. https://apps.dnr.wi.gov/dam/Dam/Detail/85*

[30] *To view the real-time streamflow in the White River downstream of the outlet dam, use the following link: dashboard.waterdata.usgs.gov/api/gwis/2.1.1/service/site?agencyCode=USGS&siteNumber=055451345&open=158330.*

[31] *For more information on these water level orders, see the permitting documents at the following link: https://permits.dnr.wi.gov/water/SitePages/DocSetViewArchive.aspx?DocSet=WP-IP-SE-2014-65-02549&Loc=waterip1&Lib=IPArchive.*

[32] *See WDNR Dam Report No. 85.*

twelve hours of heavy rainfall. During these periods, the GLLC operation protocol is to release water from the outlet gates once the water levels are seven inches above the spillway crest.[33] As a low hazard dam, the outlet dam is not required to have a dam failure analysis and no such analysis is known to have been conducted for the dam. The Commission's Community Assistance Planning Report No. 343, Fox (Illinois) Watershed Mitigation Plan provides recommendations on how to mitigate flood damage within the Fox River watershed, including Geneva Lake and its watershed.

Tributary Streams

Geneva Lake is fed by more than 50 tributary streams of varying sizes and flow (see Table 2.4 and Map 2.7). Ten of the tributaries are named and summarized below, but the vast majority are unnamed, It is estimated that the majority of these tributaries are intermittent, which means they often go dry and some of them may only discharge water during rainfall events, while others contain perennial flows year-round, sustained by groundwater inputs. Several of the tributaries have been the subject of water quality monitoring over the years that have tested for water quality parameters, estimated nutrient budgets, and inventoried sediments to describe the present hydrologic conditions as well as historic changes in the Lake.[34,35] Each of these tributaries is comprised of a variety and/or combination of urban, rural and natural land uses, different soil types, slopes, and different sized drainage areas. Given the concerns of erosion and potential pollutant contributions from these waterbodies, this study includes an assessment of these tributaries within the context of the overall water quality and watershed pollutant loading summary is Sections 2.4 and 2.5 of this report, respectively. A brief summary of specified tributaries and background information is provided below.

Abbey Springs Pond and Creek

Abbey Springs pond and creek are located on the southern side of Geneva Lake and the creek enters the lake to the east of the Abbey Springs Yacht Club building. The creek is 0.6 miles long and its reaches extend south into the Abbey Springs country club and gold greens. The Abbey Springs Pond is located withing the golf green of Abbey Springs and is partially edged by wooded land in addition to the golf greens. The pond covers just over 2 acres. Both the creek and the pond are considered "unnamed" by the WDNR. The creek

[33] *Geneva Lake Level Corporation,* High Water Dam Operation Protocol, *2018.*

[34] *Robertson, D, et al,. Water-Resources Investigations Report 02-4039* Hydrology and Water Quality of Geneva Lake, Walworth County, Wisconsin, *2002.*

[35] *Further elaboration on past tributary studies specific to particular tributaries can be found in Section 2.4.*

was part of a multi-year tributary study done by faculty and students at University of Wisconsin – Whitewater.[36]

Bigfoot Creek

Big Foot Creek is one of many tributaries that feed into Geneva Lake. This 4.86 mile long creek is located on the eastern shoreline of the Lake and empties into Buttons Bay just south of Bigfoot Beach State Park. A large portion of the creek meanders through wetlands east of the Lake, with the other portions of the creek going through agricultural lands. Part of the creak forms a distinct U-shape due to human channelization of the creek. This creek has been the subject of numerous studies over the decades due to in part the "red water" it discharges into the Lake, predominantly after heavy rains. Concern about the red water being in close proximity to the beach has been a driving factor for the monitoring and investigation into the cause of the red water. Water quality conditions and monitoring efforts in Bigfoot Creek are discussed in Section 2.4, "Water Quality."

Birches Creek

Birches Creek drains the largest subbasin in the Geneva Lake watershed and unlike most of Geneva's tributaries it has notable tributary branches. The 12 mile creek is one of two Geneva tributaries that are identified by WDNR as Second order stream.[37] This Creek was one several tributaries that were evaluated by Commission staff in a 2020 study of the Lake's tributaries.[38] Portions of the Creek's east and west branches have functional floodplains, reasonably stable channel morphology, and well vegetated riparian communities. However, like other streams feeding Geneva Lake, Birches Creek commonly carries excessive phosphorus. However, the tributary reaches in the middle of the watershed (e.g., downstream of South Lakeshore Drive but upstream of the confluence of the two main branches) appear to generate the highest phosphorus and sediment loads. This was particularly evident on the Southeast Fork of the West Branch

[36] *Splinter, Dale. "*A Late Spring-to-Early Fall Examination of Water Quality in Tributaries of the Geneva Lake Watershed: 2021-2022*" UW-Whitewater, submitted to GLEA on October 6th, 2023.*

[37] *Increasing stream order generally relates to larger drainage basins. First order streams capture diffuse overland flow and have no tributaries. Where two first order tributaries meet, a second order stream results. Similarly, where two second order streams converge, a third order stream is formed, and so on. To contrast, the Fox River directly east of Geneva Lake is a sixth order stream.*

[38] *SEWRPC Staff Memorandum: Project Overview and Preliminary Finding Geneva Lake Watershed and Tributary Inventory, Geneva Lake, Walworth County, Wisconsin, December 17, 2020.*

that roughly parallels Wooddale Drive. Recommended practices to enhance the condition of this tributary include disconnecting tile drainage at the Creek headwaters, installing grade control bands to reduce head cutting, removing buckthorn and honeysuckle along the riparian corridor, and enhancing stormwater detention structures.[39]

Buena Vista Creek

Buena Vista Creek is located in the western end of Geneva Lake. The creek empties into the lake roughly a half a mile north of the Abbey Marina. This perennial creek is 1.14 miles long and the land surrounding the creek is suburban and agriculture. Sections of the creek have little to no buffers along the bank and sections of the creek have been channelized using riprap to maintain its banks.

Covenant Harbor Creek

Covenant Harbor Creek is a 0.22-mile long stream draining a 0.36 square mile subwatershed on the northeastern side of Geneva Lake. The Creek drains agricultural fields and low-density residential areas in its headwaters before flowing under Hwy 50 and along the eastern side of the Covenant Harbor children's camp. The Creek has been the subject of two recent studies sponsored by the City of Lake Geneva and the Geneva Lake Conservancy. In 2020, the City of Lake Geneva sponsored a storm water basin detention analysis that recommended stream stabilization, construction of a detention pool, and enhancing native vegetation buffers with the intent of improving water quality in the Creek before discharge into the Lake.[40] This Creek was also included in the 2020 Geneva Lake tributary study conducted by the Commission and sponsored by the GLC.[41] This study recommended several practices intended to reduce erosion and improve water quality, including disconnecting drain tiles at the Creek headwaters, naturalizing ditched sections of the Creek, and utilizing regenerative stormwater conveyance practices.

Hillside Creek

This 0.33 mile long creek is located on the southeastern side of Geneva Lake. The creek empties into Trinke Lagoon just east of where Trinke Creek enters the Lake. The usage of the land surrounding the creek is predominantly suburban. The creek has been highly modified and in lower sections has a concrete channel

[39] *Ibid.*

[40] *Ruekert-Mielke,* Covenant Harbor Storm Water Detention Basin Analysis, City of Lake Geneva, WI, *October 2020*.

[41] *SEWRPC, 2020,* op. cit.

to direct the flow. The creek enters the lake alongside the Town of Linn's boat launch. While the creek is considered perennial, base flow for the creek is low.

Potawatomi and Van Slyke Creeks

Potawatomi Creek is a three mile long creek located on the western side of Geneva Lake in Fontana-on-Geneva that meanders through the golf greens of Big Foot Country Club and empties into the Abbey Marina after a confluence with Van Slyke Creek.[42] The Creek is fed by cold, oxygen rich groundwater springs which allow it to be considered a Class 1 trout stream by the WDNR. Van Slyke Creek, which feeds into the Potawatomi Creek, is a 0.9 mile long Class 1 trout stream. Located on the western side of Geneva Lake, a large stretch of the creek meanders through the Hildebrand Conservancy before emptying into the Abbey Marina. Similar to Potawatomi Creek, this cold, oxygen-rich creek is fed by groundwater springs making it excellent habitat for species of trout. The creek has been impacted by anthropogenic activity along the majority of its reaches. This creek also meets water quality standard set forth by the WDNR.

Both streams have been the subject of management plans intended to enhance aquatic habitat and reduce streambank erosion and pollutant loading to the Lake through various stream restoration efforts. A 2009 study sponsored by the Village of Fontana recommended replacing or removing aquatic organism passage barriers, enhancing vegetative buffer along the streams, reconstructing portions of the stream channel to reduce erosion and head cutting, and acquiring lands and/or easements along the streams to facilitate restoration work.[43] More recently, the Village of Fontana and the Abbey Marina have sponsored a study of these Creeks that recommended multiple practices intended to improve water quality and reduce sediment loading to the Lake.[44] The study highly recommended projects focused on stabilization of ravine streams and wetland restoration and assigned medium priorities to projects focused on property drainage, storm water detention, streambank stabilization, and planting of native buffers along the Creeks.

[42] *Big Foot Country Club is located at 770 Shabbona Dr, Fontana-On-Geneva Lake, WI 53125.*

[43] *Concord Ecological Engineering, Inc.,* Village of Fontana on Geneva Lake Potential Riverine Management Project, *October 2009,*

[44] *Ruekert-Mielke,* Potawatomi Creek & Abbey Harbor Watershed Analysis, Village of Fontana-on-Geneva Lake, Walworth County, Wisconsin, *June 2021.*

Shadow Lane Creek
Shadow Lane Creek is an approximately 0.8-mile stream draining agricultural fields in its headwaters before steeply dropping through forested residential areas and emptying into the south-central part of the Lake. This Creek was included in the 2020 Commission study of the Lake's tributaries.[45] This study identified channel straightening, ditching, and filling as well as contributions from agricultural fields in the Creek headwaters as issues of concern. As with other steeply sloping tributaries, regenerative stormwater conveyance practices were recommended to reduce erosion and head cutting in this tributary.

Simms Creek
Simms Creek is a 1.76 mile long creek that is most surrounded by wooded area and large lots. It enters the Lake alongside Creekside Lane in the Town of Linn. It has been noted in previous studies that flow from the creek is seemingly reduced due to a buildup of sand along the Lake's shoreline near the inlet which can cause pooling of water. During periods of high velocity flow, erosion occurs along the beach front and the resultant pooling water then enters the lake.

Southwick Creek
Southwick Creek is a 2.62 mile long tributary to Geneva Lake that empties into Williams Bay on the north side of the Lake. The creek is unique in that it has been documented to host a resident trout population, the result of relatively good water quality, ample groundwater flow into the creek, and desirable habitat substrate in section of the creek. However, since much of the stream flows through highly developed areas and is adjacent to major highways, Southwick Creek is a highly manipulated stream. The creek has been subject to ditching and channel straightening, floodplain and riparian wetland disconnection, shoreline armoring and filling, an extraordinary number of stream crossings, aggregate mining and processing in headwater areas, redirecting perennial surface-water tributaries to buried storm sewers, and heavy-handed "manicured" riparian landscaping. Due to being highly manipulated yet still maintaining moderate to good water quality, Southwick Creek is an ideal candidate for stream corridor naturalizations. Some potential projects were outlined in the 2020 report completed by the Commission, including .[46]

[45] *SEWRPC, 2020,* op. cit.

[46] *Ibid*.

Trinke Creek

Trinke Creek is a 2.1 mile long creek that empties into Trinke Lagoon on the southeastern side of the Lake. Large portions of Trinke Creek, especially in its lower reaches, have been modified to facilitate development, achieve landscaping desires, and meet landowner aesthetic preferences. This includes channel relocation, straightening, deepening, and narrowing. Modified channels, unless well engineered, are often prone to bed and bank erosion. Furthermore, channel narrowing and erosion-induced incision often disconnects streams from their floodplains, disabling natural processes that detain floodwater and reduce sediment and nutrient loads carried downstream. University of Wisconsin Whitewater water quality samples indicate that Trinke Creek's water quality is very poor and the creek is subject to intense runoff (see further discussion in Section 2.4, "Water Quality"). Trinke Creek is a good candidate for projects that detain stormwater in in its upper reaches.

Groundwater Resources

Groundwater refers to the water that has percolated into the ground and reached saturated sediment zones beneath the Earth's surface. The free-water elevation of the shallowest saturated subsurface zone is often referred to as the "water table". Groundwater is not typically visible to observation except where it discharges to surface water (e.g., springs and seeps). Water in unsaturated soil above the water table can either return to the atmosphere via evapotranspiration or may move to aquifers - the porous or fractured sediment and rock units beneath the water table - if soil moisture increases through additional percolation from the surface. In Southeastern Wisconsin, local precipitation is the source of most groundwater and essentially all groundwater is stored and moves within the natural pore spaces and fractures found in aquifers.[47] Two aquifers underlie the Geneva Lake watershed as summarized below in order of increasing depth from land surface.[48]

- **Sand and gravel aquifer.** This aquifer is found in porous, coarse-grained sand and gravel deposited primarily by glacial activity. Much of the water feeding this aquifer infiltrates the land surface in the local area. Its thickness and properties vary widely, but it underlies the majority of Walworth County, making it an important water supply. It is commonly highly vulnerable to

[47] *A common local myth suggests that water flows in underground rivers from the far north (e.g., Lake Superior). Although a few small caves are found in Southeastern Wisconsin, they are not significant contributors to overall groundwater flow and do not extend appreciable distances.*

[48] *SEWRPC Technical Report No. 37,* Groundwater Resources of Southeastern Wisconsin*, June 2002.*

contamination and over exploitation. Water quality and quantity can be significantly influenced by local land use changes. The sand and gravel aquifer is commonly in good hydraulic communication with the underlying Silurian dolomite aquifer.

- **Silurian dolomite (Niagara) aquifer.** Water in this aquifer is stored and moves primarily in bedrock fractures. Essentially all of the water found in this aquifer is derived from local precipitation that either falls upon exposed bedrock or infiltrated from the surface through porous glacial sediment. Although its water-bearing characteristics and thickness vary widely, it is relatively easy to access at a reasonable cost and is therefore a very important potable water supply aquifer. When located under a relatively thick layer of unconsolidated sediment, it is somewhat less vulnerable to contamination and overexploitation. This aquifer is sometimes referred to as the "Niagara Aquifer".

The amount, recharge, movement, and discharge of groundwater are controlled by several factors including precipitation, topography, soil permeability and structure, land use, and the water-bearing properties of underlying rock units. All residential, municipal, and industrial water supplies in the Geneva Lake watershed depend upon groundwater, making it a critical natural resource. In general, groundwater supplies in the Region are adequate to support the demands of a growing population, commerce, as well as agricultural and industrial uses. However, overexploitation of this resource could occur in areas of concentrated development, nonconductive geology, and/or intensive water demand. This resource must be wisely developed and managed so as to balance human water demands with ecosystem needs.

Groundwater sustains water levels and flow during dry weather in lakes, wetlands, and perennial streams, as well as modulates flood flows by detaining water during wet weather. Groundwater that reaches surface waterbodies is commonly referred to as "baseflow". Baseflow can either directly enter large waterbodies, or it can enter small streams, ponds, and seeps tributary to larger waterbodies. Baseflow sustains dry-weather Lake elevation and the flow of the Lake's perennial tributary streams, enabling groundwater-fed waterbodies to maintain diversity among plants and animals during drier weather periods. Groundwater typically contains little to no sediment or phosphorus, has a more stable temperature regimen, and contains a lower overall pollutant load when compared to surface water runoff- all of which are favorable to aquatic life and the ecology of waterbodies. Consequently, maintaining baseflow from the aquifers that supply the Lake, as well as the streams and wetlands that drain to the Lake are an important Lake management concern.

Groundwater supplies are naturally replenished by precipitation or runoff soaking into the ground and entering aquifers, a process often referred to as "groundwater recharge". Recharge does not necessarily occur at the point where precipitation initially strikes the Earth, uniformly throughout the landscape, or consistently throughout the year. Relatively flat, undeveloped areas underlain by thick layers of permeable soil typically contribute more water to groundwater recharge and are commonly identified as having high groundwater recharge potential. On the other hand, hilly areas underlain with low permeability (e.g., clay) soils would likely be classified as having low recharge potential. However, water running off from areas of lower groundwater recharge potential can still flow to higher groundwater recharge areas and infiltrate there, becoming a component of groundwater flow.

Most groundwater recharge occurs during periods of low natural water demand (i.e., when plants are dormant and temperatures are cool) and/or abundant precipitation or runoff. Little groundwater recharge occurs from small summer rains, even on the best sites, due to plant habitation as well as the higher evaporation rates that occur with increased temperatures which inhibit percolation that is required for recharging. The Commission has evaluated the groundwater recharge potential for all Southeastern Wisconsin[49] as a tool help in identifying areas most important to sustainable groundwater supplies. Knowledge of groundwater recharge sites can help guide decisions for planners on which areas should not be covered with impervious surfaces and/or where infiltration basins would be most effective.

In addition to identifying water recharge potential, the Commission has estimated water table elevations throughout the Region.[50] In most instances, the water table elevation reflects the surface topography. Topographically higher areas are commonly recharge areas, while lakes, wetlands, and streams are commonly groundwater discharge areas. Groundwater recharge/discharge systems occur on many spatial scales: long regional recharge/discharge relationships and short localized flow paths, both of which can be important contributors to a water body's overall water budget. While localized groundwater flow systems are commonly confined within a lake's surface watershed, regional groundwater flow paths may trace directions and distances out of phase with surface water feeding a lake. Therefore, some groundwater feeding lakes may originate in areas distant from the lake and/or outside the lake's surface watershed boundary. The relationship between short- and long-term distance flow paths is illustrated in Figure 2.6.

[49] *SEWRPC Technical Report No. 47,* Groundwater Recharge in Southeastern Wisconsin Estimated by a GIS-Based Water-Balance Method*, July 2008.*

[50] *SEWRPC Technical Report No. 37, 2002, op. cit.*

Smaller-scale local groundwater flow paths commonly approximate surface water flow paths. However, to estimate the direction of more regionally extensive flow systems, groundwater elevation contours need to be consulted. These contours can be derived from measurements collected in water supply or monitoring wells. Since water usually moves perpendicular to elevation contours, groundwater flow directions can be predicted. When performing such analyses, it is necessary to consider the locations and elevations of the streams, ponds, and lakes. This relationship can be used to predict if a surface water body is fed by, recharges, or has little interaction with groundwater. By combining these data, maps can be prepared identifying those land areas that are likely to contribute recharge and are, therefore, sources of baseflow to a surface water feature conveying groundwater directly to a lake.

As shown in Figure 2.7, a waterbody gains water when groundwater elevations are higher than the adjacent waterbody. Conversely, a perennial waterbody loses water wherever the water table elevation is lower than the waterbody's elevation. In such instances (e.g., ephemeral streams), the water table may not be in contact with the surface water feature. The rate at which water flows between a stream and its adjoining aquifer depends on the hydraulic gradient between the two waterbodies, as well as the hydraulic conductivity of geologic materials that are located at the groundwater/surface-water interface. For example, a clayey streambed will reduce the rate of flow between a stream and aquifer compared to a sandy or gravelly streambed. In the absence of surface water contributions, streamflow volume increases along gaining reaches and decreases along losing reaches. Streams can have both gaining and losing reaches and the extent of these reaches may change based upon the prevailing conditions. Since precipitation rates, evapotranspiration, water table elevations, and human-induced hydrologic stressors vary with time, a particular stream reach can switch from a gaining to a losing condition or vice-versa from one period to the next.

Human Influences on Groundwater

Humans deplete groundwater in two primary ways: 1) be actively pumping water from aquifers, which reduces, or in extreme cases eliminates, natural groundwater discharge through springs and seeps, and 2) by reducing groundwater recharge through land use changes that increase impervious cover and/or hasten runoff.

Land use can profoundly alter the ability for an area to absorb water and contribute to groundwater recharge. Most areas developed greater than 30 years ago route stormwater runoff directly to surface waters, discouraging groundwater recharge. Despite requirements of Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* calling to detain/infiltrate runoff from new developments where practicable, such developments still have cumulative effects that reduce groundwater recharge compared to pre-development conditions. Urban developments decrease groundwater recharge potential by placing additional demand on groundwater supplies as water is extracted for various uses. The removal of this groundwater from its natural flowpath often reduces groundwater elevations and the volume of natural groundwater discharge to surface waterbodies.

Depletion through artificial groundwater abstraction, the process of taking water from underground sources (e.g., aquifers), most commonly occurs when high-capacity wells, numerous smaller wells, or dewatering systems used in development are operated without considering the effect pumping may have on naturally occurring groundwater discharge areas. Wells developed in shallow aquifers often provide sufficient yield, but can negatively impact nearby surface water resources and are generally more vulnerable to contamination than deeper bedrock wells. Communities tapping these shallow aquifers also face choices between using numerous low-capacity household wells or developing a municipal water system with homeowners connecting to high-capacity municipal wells. In some cases, some watersheds have an overall negative groundwater balance because water pumped from watershed aquifers is piped to wastewater treatment plants that discharge to waterbodies outside of the watershed. In cases where the development of high-capacity wells in the shallow aquifer could negatively affect surface water resources, the Commission's Regional Water Supply Plan recommends conducting studies to evaluate potential negative effects.[51] This plan also calls for installing systems to enhance infiltration in areas where studies indicate a potential significant reduction in baseflow to surface waters.

In addition to groundwater abstraction, groundwater recharge can be reduced by several other means, such as hastening stormwater runoff, eliminating native vegetative cover, reducing soil's ability to absorb water (e.g., compaction, disrupted structure), draining of wet areas such as ditching or tiling, disconnecting floodplains from streams, and increasing the amount of impervious land cover. Such factors all contribute to reduced stormwater infiltration and increased runoff, thereby reducing groundwater recharge. Similarly,

[51] *SEWRPC Planning Report No. 52,* A Regional Water Supply Plan for Southeastern Wisconsin*, December 2010.*

if sanitary sewers are installed in areas currently served by private onsite wastewater treatment systems, much of the water that re-enters the shallow aquifer is often conveyed to downstream discharge points outside of the watershed. Consequently, more groundwater may be taken than returned, reducing the volume of groundwater re-entering a lake or a stream. Development and land management activities need to consider groundwater recharge, as well as prioritize actions to protect and enhance recharge. For example, some communities have passed groundwater ordinances to protect precious resource elements and help assure groundwater supplies are sustainable in the long term.[52]

Groundwater Conditions

The USGS maintains a groundwater monitoring well just west of Geneva Lake in the Village of Fontana that reports daily depth to water level in feet below the land surface using the National Geodetic Vertical Datum (NAVD 88).[53] In November 2019, this well had water elevations at approximately 942 feet NAVD 88 (approximately 104 feet below the land surface). As June 2025, the well had water elevations at 934 feet NAVD 88 (approximately 111.5 feet below the land surface). The 7.5 foot decrease in water elevation over this time frame may reflect the impacts of increased groundwater pumping, but it also may be influenced by several above average precipitation years in the years preceding the initial measurements.

To help determine where management efforts could best protect groundwater recharge to aquifers feeding Geneva Lake, Commission staff analyzed water table elevation contours and groundwater recharge potential in the areas surrounding the Lake[54,55] This inventory was not confined to the surface watershed (as was the case for the other inventories completed in this report) because the groundwater flow paths may extend outside of the surface water watershed. Water table elevation contours for the Geneva Lake area are shown in Map 2.8, with enlarged versions available in Appendix A.1-A.5.[56] Depth to groundwater varies considerably across the landscape. In and near waterbodies and wetlands, the water table is near or at the land surface whereas it can be over one hundred feet or more below the land's surface in upland

[52]*The Village of Richfield in Washington County passed a groundwater ordinance over 15 years ago and uses the ordinance as a tool to encourage development that is consistent with long-term sustainability. More information can be found about Richfield's groundwater ordinance at the following website: www.richfieldwi.gov/index.aspx?NID=300.*
[53] *https://waterdata.usgs.gov/nwis/dv?referred_module=sw&site_no=423312088350401*

[54]*SEWRPC Technical Report Number 37,* Groundwater Resources of Southeastern Wisconsin*, June 2002.*
[55]*SEWRPC Planning Report No. 52, December 2010,* op. cit.
[56]*The groundwater maps are a compilation of several reports prepared by UW-Extension, Wisconin Geological and Natural History Survey, and the Geneva Lake Environmental Gency. The publications can be found at https://www.gleawi.org/publications.*

areas near the periphery of the watershed.[57] The Commission used water table elevations to estimate the area where water infiltrating into the land surface ultimately reaches Geneva Lake. This Commission-delineated groundwatershed was combined with a groundwatershed produced by the Wisconsin Geological and Natural History Survey and University of Wisconsin – Extension in 2009 to indicate the entire potential area contributing groundwater to the Lake.[58] This area is the source for water issuing as springs and seeps to the Lakes, its tributaries, and associated wetlands. Map 2.8 also illustrates the extent of the Lake's 33,577-acre groundwatershed. Although the groundwatershed overlaps much of the Lake's watershed, it extends further to the west, south, and north than the watershed. Groundwater is a significant contributor to Potawatomi and Van Slyke Creeks, which are two coldwater streams that enter the Lake along its western shore in the Village of Fontana-on-Geneva-Lake. The eastern shoreline of Geneva Lake and a portion of the north-central shoreline do not contribute groundwater to the Lake. Along the eastern shoreline, groundwater in this area contributes to the White River downstream of the Lake. Groundwater near the north-central shoreline contributes to Como Lake north of Geneva Lake.

Evaluating groundwater recharge potential helps identify portions of a groundwatershed most important to sustaining a waterbody's seeps and springs. The Commission evaluated groundwater recharge potential for all Southeastern Wisconsin.[59] Such data can help planners decide which areas should not be covered with impervious surfaces and/or where infiltration basins would be most effective. The distribution of various groundwater recharge potential categories for Geneva Lake's groundwatershed are illustrated in Map 2.8. Most of the groundwatershed has moderate groundwater recharge potential with pockets of high and very high recharge scattered throughout. Preserving and enhancing recharge potential within the groundwatershed, especially in the areas identified as having high and very high recharge potential, is essential to protecting the groundwater feeding the Lake and its tributaries. High and very high recharge potential sites should remain substantially open and may provide ideal sites to position stormwater infrastructure designed to infiltrate detained stormwater.[60] Infiltrating stormwater helps reduce peak flows and increases cool, high quality baseflow to waterbodies during dry periods, conditions that generally improve waterbody health.

[57]*The depth to groundwater for a particular location can be estimated by subtracting groundwater elevation values from surface topography values.*
[58] *M. Gotkowitz, 2009*, op. cit.

[59]*SEWRPC Technical Report No. 47,* op. cit.
[60]*Care needs to be taken to infiltrate water that does not degrade the quality of groundwater resources. More information regarding stormwater infiltration is available from many sources, including the following website: learningstore.uwex.edu/assets/pdfs/g3691-3.pdf.*

In the Geneva Lake groundwatershed, the Maquoketa shale layer underlies Geneva Lake and much of the shallow sand and gravel aquifer below the Lake. This shale layer is a confining unit that limits groundwater flows from the shallow aquifer to the deeper aquifers below. However, this shale layer does not extend to the western portion of the groundwatershed, so groundwater infiltration in these areas can recharge the deeper aquifers.

Numerous wells are found throughout the groundwatershed, with several high-capacity wells located in the western extent. The 2009 study by the Wisconsin Geological and Natural History Survey and the University of Wisconsin – Extension found that these wells limited the extent of the pre-development groundwatershed and reduced the groundwater contributions to the Lake by 9 percent under 2006 conditions (see Map 2.8).[61] These wells contribute to the modeled gaps and cuts in the Lake's groundwatershed along its western section. Harris, Gardens, and Potawatomi Creeks also had substantially reduced groundwater contributions under 2006 pumping conditions. This impacts reduced the overall lake volume by 4 percent under 2006 pumping conditions and by up to 4.5 percent under planned 2035 land use conditions. As noted earlier in this chapter, this study identified groundwater as contributing a much large portion of the overall water budget than earlier water budgets constructed for the lake.[62] Loss of groundwater contributions from pumping and from reduced groundwater recharge are likely to negatively impact both the quantity and quality of the Lake and several of its tributaries, particularly those along its western shoreline. Therefore, human demands placed on groundwater supplies should be considered as part of lake management planning.

All wastewater discharged to public sanitary sewers within the Geneva Lake watershed is exported from the Lake's watershed to the WalCoMet treatment facility on Turtle Creek or to the Lake Geneva Wastewater Plant downstream of the Lake on the White River. Since the water discharged to sanitary sewers originates as groundwater drawn from within the watershed, household water use in areas served by public wastewater collection systems represents a small net artificial demand placed upon the groundwater flow system feeding waterbodies in the watershed. This slightly decreases the volume of groundwater discharging to the watershed's waterbodies.

[61] *M. Gotkowitz, 2009*, op. cit.

[62] *SEWRPC CAPR No. 60 (2nd Edition), 2008,* op. cit.

Groundwater is the water supply for all the residences, agriculture, and industry within the Geneva Lake watershed. Additionally, it is a critical source of cool, clean water to the Lake, several of its tributaries, and the White River; this source helps maintain surface water elevations and stream baseflow during dry periods. However, human activities can imperil groundwater resources, particularly by depleting groundwater through excessive abstraction, constructing impervious surfaces on important groundwater recharge areas, and contaminating groundwater with pollutants.[63] Protecting high recharge areas from coverage by impervious surface and reducing nonpoint source pollution will preserve the quality and supply of groundwater within the watershed.

2.3 HUMAN USE AND OCCUPATION

Historical Land Use

Knowledge of historical urban growth and development patterns can not only help correlate waterbody changes to human influences but can additionally aid in predicting future changes. Significant urban development began to occur in the early 20th century, with the most significant development taking place from 1940 to 1963 (Map 2.9) During this period, 2,600 acres of the tributary area were converted from rural to urban land uses, particularly in the western portion of the watershed. Projected slight decreases in agricultural land uses for the conversion to urbanized uses is expected for the watershed going forward, but at much lower rates.

2020 and Planned Land Use

The Commission periodically quantifies the ways humans use land in Southeastern Wisconsin and projects how land use will change over time in the near term. Existing land uses in the Geneva Lake watershed were last evaluated in 2020. As of 2020, surface waters accounted for most of the watershed totaling about 5,494 acres (25 percent); most of this area is Geneva Lake itself (see Table 2.5 and Map 2.10). Single-family residential housing was the second-most dominant land use, totaling over 17 percent of the watershed, followed by agriculture at over 14 percent, and woodlands at 13 percent. Single-family residential areas were found throughout the watershed, as several municipalities are located within the tributary as well as along the Lake’s shoreline. Agricultural areas were mostly found in the low elevation areas in the

[63]It should be remembered that pollutants can include seemingly innocuous substances such as sodium chloride (the same as simple table salt). In some parts of the region, groundwater now contains concentrations of salt in excess of drinking water quality standards.

southeastern portion of the watershed, while woodlands were most commonly found in the northeast and southwest portions. No major land changes are anticipated for the watershed with planned land use (see Map 2.11). Slight decreases in lands currently used for agriculture are expected while commercial, industrial, and low-density residential uses will all slightly increase, occupying these formerly agricultural areas.

The located 'urban reserve' areas indicate that the municipality has recognized those areas to be developed at some point, but no specific future uses have been determined. In many cases, the identified urban reserve areas are located adjacent to municipalities, often being located wholly or partially within the planned sewer service areas and could be annexed prior to development. In other cases, the urban reserve areas would remain part of the municipality concerned. Some municipalities envision a broad range of future land uses within the urban reserve areas, while others envision a narrower range of uses. The 'urban reserve' designation is not to be construed as limiting future development to urban density residential or other urban uses. Urban reserve areas within the Lake's watershed are generally located on in the western fringes of the tributary area as well as on the eastern end within both the Town and Village of Bloomfield. There are over 553 acres of designated urban reserve areas within the Lake's watershed.

Political Jurisdictions,

Geneva Lake is located in the City of Lake Geneva, the Villages of Fontana-on-Geneva Lake and Williams Bay, and the Towns of Linn and Walworth. With approximately 21 miles of shoreline, 49 percent of the shoreline is within the Town of Linn, 18.9 percent within the Village of Williams Bay, 15.8 percent within the City of Lake Geneva, 15 percent within the Village of Fontana-on-Geneva-Lake, and 1.2 percent within the Town of Walworth. The entire area tributary to Geneva Lake includes portions of the Towns of Bloomfield, Delavan, Geneva, Linn and Walworth; the City of Lake Geneva; and the Villages of Fontana-on-Geneva Lake, Walworth, and Williams Bay (see Map 2.1).

Sewer Service Area

Sewer service areas are delineated through a local sewer service area planning process. As part of this process, communities, assisted by the Commission, define a public sewer service area boundary that is consistent with local land use plans and development objectives. Sewer service area plans include detailed maps of environmentally significant areas within the sewer service area. Following plan adoption by the designated management agency for the wastewater treatment plant, the Commission considers local sewer service area plans for adoption. Once adopted by the Commission, the plans become a formal amendment to the regional water quality management plan and the Commission forwards the plans to the Wisconsin Department of Natural Resources for approval.

There are three sewer service areas within the Geneva Lake watershed, totaling to 7,257 acres, or 39 percent, of the Lake's watershed (see Map 2.12). All three wastewater treatment plants lay outside of the Geneva Lake watershed, later dispersing treated effluent outside of Geneva Lake's tributary area.[64] Since water discharged to sanitary sewers originates as groundwater drawn from the watershed, household water use in areas served by public wastewater collection systems place a small net artificial demand upon the groundwater flow system feeding waterbodies in the Geneva Lake watershed. This slightly decreases the volume of groundwater discharging to the watershed's waterbodies. The remaining 61 percent of the watershed is served by private on-site systems and found in the City of Lake Geneva and the Towns of Geneva and Linn. The Linn Sanitary District provides de-centralized wastewater treatment and well-inspections to ensure that both ground and drinking water are safe for the residents and Geneva Lake.[65]

Natural Resource Elements

Natural resource elements are vital to continued environmental health, as their features remain integral to the Southeastern Wisconsin landscape, provisioning many human needs and desires. The ability of natural resource elements to provide for these needs and desires as well as to support ecology is built upon a complex network of abiotic and biotic relationships. Deterioration or removal of one important relationship may damage the entire network. For example, draining a wetland can eliminate the area's ability to supply important fish reproduction, nursery, and refuge functions. It may also compromise upland wildlife habitat value, interrupt important groundwater recharge/discharge relationships, and can inhibit natural runoff filtration and floodwater storage. This loss in ecosystem function may further affect groundwater supply for domestic, municipal, and industrial uses, or its ability to aid in maintaining dry-weather flows in streams and rivers. Preserving natural resource elements not only improves local environmental quality, but it can also sustain - and possibly enhance - aquatic, avian, and terrestrial wildlife populations across the Region.

[64] *J. Carter and M. Gotkowitz, '*A Groundwater Flow Model for the Geneva Lake Area, Walworth Co. WI*, UW-Extension, February, 2009. https://wgnhs.wisc.edu/pubshare/WOFR2009-02.pdf.*

[65] *For more information about the Linn Sanitary District, visit https://townoflinn.wi.gov/sanitary-district/.*

Floodplains

Section 87.30 of the *Wisconsin Statutes* requires that counties, cities, and villages adopt floodplain zoning to preserve floodwater conveyance and storage capacity, as well as prevent new flood-damage-prone development in flood hazard areas. The minimum standards that such ordinances must meet are set forth in Chapter NR 116, "*Wisconsin's Floodplain Management Program*" of the *Wisconsin Administrative Code*. The required regulations govern filling and development within a regulatory floodplain, which is defined as an area that has a 1-percent annual probability of being inundated. The 1-percent annual probability (100-year recurrence interval) floodplains within the Geneva Lake watershed are shown on Map 2.13. As required under Chapter NR 116, local flood land zoning regulations must prohibit nearly all development within the floodway, which is that portion of the floodplain actively conveying flowing water during the 1-percent annual probability flood flow. Local regulations must also restrict filling and development within the flood fringe, which is that portion of the floodplain located below the floodway that is inundated during the one-percent annual probability flood, detaining floodwater for later release. Filling within the flood fringe reduces floodwater storage capacity and may increase downstream flood flows, depths, and elevations. Approximately 5,595 acres of floodplain are present within the Geneva Lake watershed.

Ordinances related to floodplain zoning recognize existing uses and structures to regulate them in accordance with sound floodplain management practices. These ordinances are intended to: 1) regulate and diminish proliferation of nonconforming structures and uses in floodplain areas; 2) regulate reconstruction, remodeling, conversion and repair of such nonconforming structures- with the overall intent of lessening public responsibilities generated by continued and expanded development of land and structures inherently incompatible with natural floodplains; and 3) lessen potential danger to life, safety, health, and welfare of persons whose lands are subject to the hazards of floods.

Wetlands

Historically, wetlands were largely viewed as wastelands, lands presenting obstacles to agricultural production and development. Private interests as well as governmental institutions supported the transformation of wetlands through large-scale draining and filling. Wetland habitat was aggressively removed until scientific research revealed their value as incredibly production and biologically diverse ecosystems.[66] Wetlands are most known for their variety of plant life, with communities composed of a mixture of submergent pondweeds (*Potamogeton* spp.) floating leaf plants, emergent cattails, bulrush (*Schoenoplectus* spp. and *Scirpus* spp.), woody shrubs, and tamaracks (*Larix lacarina*), as just a few examples. Wildlife species that rely on, or are associated with, wetlands for at least part of their lives include crustaceans, mollusks, and other aquatic insect larvae and adults; fishes, including forage fish and important gamefish species like trout, northern pike, and largemouth bass; amphibians; reptiles; mammals including deer; and resident bird species like turkey as well as migrants like sandhill or whooping cranes. Thus, wetlands help maintain biologically diverse communities of ecological and economic value.

In addition to maintaining biodiversity, wetlands also store runoff and floodwater; filter pollutants; improve water quality; sustain groundwater aquifers; serve as sinks, sources, or transformers of materials; and provide recreation sites for boating or fishing. Recognition of the value and importance of wetlands led to the creation of rules and regulations protecting wetlands globally, nationally (i.e. the Federal Clean Water Act of 1972), statewide, and locally. These efforts are designed to protect or conserve wetlands and the ecosystem services they provide. The term "ecosystem services" refers to any of the benefits that ecosystems, both natural and semi-natural, provide to humans.[67] In other words, ecosystem functions are classified by their abilities to provide goods and services that satisfy human needs,[68] either directly or indirectly. Examples of ecosystem services provided by wetland include floodwater detention, lessening flood severity in downstream areas; nutrient, sediment, and pollutant processing and retention that improves downstream water quality; aquatic organism, bird, amphibian, and terrestrial wildlife breeding, nursery, feeding, and refuge; and human recreational opportunities. The economic value of the ecosystem services provided by wetlands exceeds those provided by lakes, streams, rivers, forests, and grasslands and

[66] *J.A. Cherry, "Ecology of Wetland Ecosystems: Water, Substrate, and Life,"* Nature Education Knowledge, *3(10): 16, 2012, www.nature.com/scitable/knowledge/library/ecology-of-wetland-ecosystems-water-substrate-and-17059765.*

[67] *Millennium Ecosystem Assessment,* Ecosystem Services and Human Well-Being: Wetlands and Water, *Synthesis. Report to the Ramsar Convention. Washington D.C.: World Resources Institute, 2005, www.millenniumassessment.org/en/Global.html.*

[68] *R.D.S. de Groot, M.A. Wilson, and R.A.M. Bauman, "A Typology for the Classication, Description, and Valuation of Ecosystem Functions, Goods, and Services,"* Ecological Economics*, 41:393-408, 2000, www.sciencedirect.com/science/article/pii/S0921800902000897.*

is only second to the value provided by coastal estuaries.[69] Society gains a great deal from wetland conservation. Therefore, it is essential to incorporate wetland conversation and restoration targets as part of this plan.

Wetlands are transitional areas that often possess characteristics of both aquatic and terrestrial ecosystems, while at the same time possessing features unique on to themselves. For regulatory purposes, the State of Wisconsin defines wetlands as areas where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophilic vegetation and which as soils indicative of wet conditions. Three specific characteristics of wetlands are evaluated when a wetland determination is made including:

- Hydrology that results in wet or flooded soils
- Soils that are dominated by anerobic (without oxygen) processes
- Rooted vascular plants that are adapted to life in flooded, anaerobic environments

These characteristics pose severe limitations for urban development, as wetland areas have shallow water tables, soils that are highly compressible, unstable, high shrink-swell potential, and have low bearing capacity. Thus, development in wetlands may result in flooding, wet basements, unstable foundations, failing pavement, and failing sanitary sewer and water lines. Furthermore, significant and costly onsite preparation and maintenance costs associated with developing wetland soils, particularly regarding roads, foundations, and public utilities.

Within the Geneva Lake watershed, wetlands total approximately 689 acres, or about 3 percent of the total watershed area (see Map 2.14). The wetlands vary by ecological community type and include aquatic beds, emergent/wet meadows, scrub/shrub, and forested wetlands. Each wetland community type has unique sets of flora and fauna, and provides distinct ecosystem services.

[69] *R.W. Costanza, R. d'Arge, R. de Groot, et al., "The Value of the World's Ecosystem Services and Natural Capital,"* Nature, *387(6630): 253-260, 1997.*

Environmental Corridors and Natural Resource Areas

The Commission has studied the distribution of natural resource elements in Southeastern Wisconsin for decades labeling, ranking, and mapping important natural resource elements. This section provides a brief overview of high-value areas located within the Geneva Lake watershed.[70]

Primary Environmental Corridors

Primary environmental corridors (PECs) include a wide variety of important resource and resource-related elements. By definition, they are at least 400 acres in size, two miles in length, and 200 feet in width.[71] There are about 8,482 acres of PECs in the watershed under existing conditions, equating to about 29 percent of the tributary area. Geneva Lake alone contributes 5,356 acres of PEC, making up around 63 percent of the total acreage of PEC within its watershed. The identified PECs represent a composite of the best remaining elements of the natural resource base in the watershed, containing almost all of the best remaining uplands, wetlands, and wildlife habitat areas (see "*Natural Areas and Critical Species Habitat Sites*" section below). This is why management of those areas is vital to protecting and maintaining the quality and integrity of this resource.[72]

Secondary Environmental Corridors

Secondary environmental corridors (SEC) are remnant resources that have been reduced in size compared to larger PECs due to land developed for intensive urban or agriculture land uses. SEC are at least 100 acres in size and one mile long. In 2020, as shown on Map 2.15, there were about 46 acres of designated secondary environmental corridors within the Geneva Lake watershed, accounting for about 0.2 percent of its area. Although these areas are small compared to the PEC, they provide vital connections between PEC and Isolated Natural Resource Areas (see below). They additionally preserve ecosystem functions by facilitating surface water drainage, maintaining pockets of natural resource features, providing corridors for the movement of wildlife and dispersal of vegetation seeds, and oftentimes provide a protective buffer for PECs.

[70] *Information from data collected in 2020. Previous edition of Geneva Lake's plan utilized data collected in the year 2000.*

[71]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, Amendment*, December 2010.*

[72]*For more information, see www.sewrpc.org/SEWRPCFiles/Publications/ppr/rbmg-001-managing-the-waters-edge.pdf.*

Isolated Natural Resource Areas

Smaller concentrations of natural resource features that have been separated physically from environmental corridors by intensive agricultural or urban land uses have also been identified. These natural resource areas, which are at least five acres in size, are referred to as isolated natural resource areas (INRA) and are shown on Map 2.15. Widely scattered throughout the watershed, isolated natural resource areas covered about 411 acres, or 2 percent, of the total study area in 2020. These INRAs still contain a variety of resource functions, and if connected with other INRAs, SECs, or PECs, could enhance the corridor systems and wildlife areas within the watershed.

Natural Areas and Critical Species Habitat Sites

Natural areas, as defined by the Wisconsin Natural Areas Preservation Council, are tracts of land or water so little modified by human activity, or sufficiently recovered from the effects of such activity, that they contain intact native plant and animal communities believed to be representative of the pre-European settlement landscape (see Map 2.16). Natural areas are generally comprised of wetland or upland vegetation communities and/or complex combinations of both these fundamental ecosystem units. In fact, some of the highest quality natural areas within the Southeastern Wisconsin Region, as well as in the Geneva Lake watershed, are wetland complexes that have maintained adequate or undisturbed linkages (i.e., landscape connectivity) between the upland-wetland habitats, which is consistent with research findings in other areas of the Midwest.[73]

Natural areas have been identified for the seven-county Southeastern Wisconsin Region in SEWRPC Planning Report No. 42, "A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin,' published in September 1997 and amended in 2008 and 2020. This plan was developed to assist Federal, State, and local agencies and governmental units as well as non-governmental organizations make environmentally sound land use decisions. This includes prioritizing conservation program funding and property acquisition, managing public lands, and developing land in a fashion that helps protect and preserve the natural resource base of the Region. Walworth County uses SEWRPC Planning Report No. 42 to guide land use decisions.

Planning Report No. 42 classifies natural areas into the following three categories

[73] *O. Attum, Y.M. Lee, J.H. Roe, and B.A. Kingsbury, "Wetland complexes and upland-wetland linkages: landscape effects on the distribution of rare and common wetland reptiles,"* Journal of Zoology *275: 245-251, 2008.*

1. Natural area of statewide or greater significance (NA-1)
2. Natural area of countywide or regional significance (NA-2)
3. Natural area of local significance (NA-3)

Assigning a particular area into one of these three categories was based upon several factors, including consideration of the diversity of plant and animal species; the community types present; native plant community structure, integrity, and frequency of occurrence within the Region; the extent of disturbance by human activity (such as logging, grazing, water level changes, and pollution); the occurrence of unique natural features within the area; the size of the area; and the educational value. Geneva Lake watershed contained 10 areas of local significance, totaling to 765 acres, as of 2020.

As part of 2020 amendment, aquatic natural areas were given a separate rank of AQ- 1, 2, or 3 for their level of significance, similar to those of natural areas.[74] However, aquatic natural areas were ranked on new, separate criteria to better encompass what beneficial services they provide. These criteria included: the waterbody morphology and natural community, with more rare communities receiving higher scores; water quality to support aquatic life; the quality of the aquatic plant and fish communities; presence of riparian buffers; connectivity to other natural areas; and presence of rare or threatened species. Geneva Lake was ranked as an AQ-1, indicating that it is a waterbody of statewide significance. Harris Creek, which enters the Lake in Williams Bay, attained a AQ-2 ranking, indicating that it is a waterbody of County-wide or regional significance. Birches Creek, located in the south central portion of the watershed, received an AQ-3 ranking indicating a waterbody of local significance.

Within or immediately adjacent to bodies of water, the WDNR, pursuant to authority granted under Chapter 30 of the *Wisconsin State Statutes* and Chapter NR 107 of the *Wisconsin Administrative Code*, designates environmentally sensitive areas on lakes. These areas have special biological, geological, ecological, or archaeological significance, 'offering critical or unique fish and wildlife habitat, including season or life-stage requirements, or offering water quality or erosion control benefits of the body of water." Wisconsin law mandates special protections for these "sensitive areas" or "Critical Habitat Designation" areas, which are home to approximately eighty percent of the plants and animals on the state's endangered and

[74] *For more information and supplemental visualization of all ranking sites, please visit the Natural Areas Explorer Webtool, https://experience.arcgis.com/experience/f6c9f898efc0474eae09191beb0f7ebf/.*

threatened species list. A significant part of the critical habitat designation lies in the fact that it assists waterfront owners recognize these areas so that they can design their waterfront projects to protect habitat and ensure the long-term health of the lake where they live. If a project is proposed in a designated Critical Species Habitat area, the permit process allows WDNR to ensure that the proposed projects will not harm sensitive resources. Critical habitat areas in the Geneva Lake watershed are located on Map 2.16.

Park and Open Space Sites

Maintaining parks and other open space sites are one way to allow for the continued conservancy of greenspace and other high-value natural resources within the Region. The preservation of sufficient open space lands and their underlying natural resource base can in turn allow enhancement of social and economic well-being, environmental quality, and biodiversity.[75] The Geneva Lake watershed contains a total of 2,505 acres of protected public and privately-owned park and open space sites (see Map 2.17 and Table 2.6).

Agricultural Practices

Agricultural land uses constitute 14 percent of the Geneva Lake watershed and are predominantly located on uplands near the boundaries of the watershed. Commission staff utilized the USDA CropScape tool to evaluate the most common crops within the Lake watershed.[76] The CropScape tool allows users to view and download the USDA Cropland Data Layer, which is an annual spatial dataset that estimates land coverage by specific crops and other land uses at a 30-meter spatial resolution. The most common crops within the watershed in 2024 were corn, soybeans, grassland/pasture, and alfalfa. Many producers within the watershed are utilizing rotations of these crops, such as rotating corn and soy in alternate years or producing two years of corn followed by one year of soy.

Forming an upland shelf around the Lake, these agricultural lands feed steep-gradient tributary streams that rapidly transport eroded sediments and nutrients from the agricultural fields into the Lake. Pollutant loading from these areas can be exacerbated by use of drain tiles, which rapidly channel water from fields into these tributary streams which can worse streambank erosion and head-cutting. Walworth County and

[75] *SEWRPC Community Assistance Planning Report No. 135 (4th ed.)* A Park and Open Space Plan for Walworth County, *July 2022.*

[76] *United States Department of Agriculture National Agricultural Statistics Service, Cropland Data Layer: USDA NASS, https://croplandcros.scinet.usda.gov/.*

WDNR staff have worked with agricultural producers in the watershed to implement best management practices that reduce soil loss from farmland and mitigate pollutant loading to the Lake. These practices include cover crops, reduced tillage, nutrient management planning, and grassed waterways. Using 2024 aerial imagery, Commission staff estimated that 13,645 feet of grassed waterways have already been implemented within the watershed, including waterways in fields draining to Bigfoot, Birches, and Trinke Creeks.[77] Based on analysis of topographic contours and visible erosion in aerial imagery, 53,800 linear feet of new grassed waterways could be implemented to help further control soil loss in the watershed (see Map 2.18).

Animal Operations

In Wisconsin, an animal feeding operation with 1,000 or more animal units is defined as a Concentrated Animal Feeding Operation (CAFO).[78] Under state and federal law, CAFOs must have a WDNR-issued Wisconsin Pollutant Discharge Elimination System (WPDES) permit to protect surface and ground waters from excessive runoff and animal waste. Consequently, CAFOs are more stringently monitored and regulated than smaller animal feeding operations. Among the requirements are that CAFOs have a nutrient management plan developed as part of the permit process; that response plans are developed for manure and non-manure spills; that manure spreading limits and setbacks are specified; and that additional inspection, monitoring, and reporting requirements are adhered to.[79]

Two CAFOs (Merry-Waters Farm, Inc. and Snudden Farms, LLC) operate within the watershed. As part of their WPDES permits, these CAFOs are required by the WDNR to provide annual reports on manure production and storage, livestock counts and plans, soil samples, manure application plans, identified fields for manure spreading, and maps of conduits to surface waters and drinking water wells in relation to those fields. Merry-Waters Farm, Inc. is a dairy located on Hillside Road just south of the watershed, operates within the watershed. This CAFO reported 3,800 animal units as of January 27th, 2022 and produced

[77] Personal communication between Commission staff (Justin Poinsatte) and Walworth County staff (Brian Smetana), March 2023.

[78] Wisconsin Administrative Code NR 243 Animal Feeding Operations relates an animal unit to the impact of one beef steer or cow. Therefore, 1000 beef cattle are equivalent to 1000 animal units. Other animals have differing ratios. For example, the following numbers of animals are equivalent to 1000 animal units: 500 horses, 715 dairy cattle, 5,000 calves, 5,500 turkeys, 10,000 sheep.

[79] For more information, see www.dnr.wisconsin.gov/topic/CAFO/WPDESNR243.html.

approximately 23,214,094 gallons of manure and process wastewater as well as approximately 1,777 tons of solid manure. This manure is spread in spring before planting and in fall after harvest across 7,068 acres; only a small portion of these fields, located near S Lake Shore Drive, are within the Geneva Lake watershed. Snudden Farms LLC is a dairy with 5,934.5 animal units located on Zenda Road south of the watershed. In 2024, this CAFO produced 45,000,000 gallons of manure and process wastewater and 7,000 tons of manure. This manure was spread across 3,107 acres, but only a small portion of the fields associated with this CAFO are located within the watershed. As part of their WPDES permits, Merry-Waters Inc. and Snudden Farms, LLC have their fields enrolled in nutrient management plans that are approved by WDNR staff.

Stormwater Management

To meet the requirements of the Federal Clean Water Act, the WDNR developed a permit program under Wisconsin Administrative Code NR 216, "Storm Water Discharge Permits." A municipal separate storm sewer system (MS4) permit is required for a municipality that is either located within a Federally-designated urbanized area, has a population of 10,000 or more, or is designated for permit coverage by the WDNR. Municipal permits require stormwater management programs to reduce polluted stormwater runoff by implementing best management practices, such as detention basins, street sweeping, filter strips, bioretention facilities, and rain gardens. There are no MS4 municipalities within the Geneva Lake watershed. Chapter NR 216 also requires certain types of industries to obtain stormwater discharge permits from the WDNR. The only industrial stormwater permit issued near Geneva Lake is a "no-exposure" certification for the Abbey Harbor Condominium, which means that all industrial materials are protected from runoff by a storm resistant shelter.[80]

With assistance from GLC staff, the Commission compiled available information regarding stormwater management for the municipalities around Geneva Lake. The Village of Fontana-on-Geneva-Lake has a stormwater management plan while the City of Lake Geneva, Village of Williams Bay, and Towns of Linn and Walworth do not have stormwater management plans. Commission staff also reviewed aerial imagery to identify the location of 24 stormwater management ponds within the watershed (see Map 2.19). These basins were projected over the total extent of urban lands under pre-1990 versus post-1990 conditions, because stormwater rules and practices began to be implemented more widely during the post-1990 period. Due to only having location data for one type of stormwater BMP, there is no distinct correlation

[80] *https://apps.dnr.wi.gov/swampereporting/stormwater/detailInd/77320*

between the ponds and development in this map. Inclusion of the locations of other BMPs would be beneficial in future comprehensive analyses of urban development and stormwater BMPs.

The City of Lake Geneva has municipal ordinance for long-term, post-construction stormwater management that applies to post-construction sites and residential developments with land-disturbing activity.[81] This ordinance recommends design standards and BMPs to increase infiltration, defines protected areas, and requires permits for land-disturbing construction activity. Additionally, the 2022 City of Lake Geneva comprehensive plan recommends protecting the water quality of Geneva Lake by retaining stormwater using BMPs, enforcing erosion control and stormwater management standards through overlay zoning districts such as the Drainageway Zoning District, and completing a stormwater management and climate resiliency plan.[82]

Following several severe rainfall events in 2007 and 2008, the Village of Fontana-on-Geneva-Lake formed a Stormwater Advisory Committee to develop a Village stormwater management plan and Stormwater Utility District. Completed in 2009, the management plan described the existing stormwater management infrastructure, provided a set of standards and design criteria for infrastructure, identified reoccurring areas of concern and recommendations to address issues in these areas, and recommended a strategy to implement the plan (see Figure 2.8). At the time of stormwater plan publication, the Village used pipes, inlets, catch and detention basins, culverts, ditches, and overland flow paths to manage stormwater with over seven miles of sewers and culverts.

The Village of Williams Bay has municipal ordinances governing stormwater management during land development and construction.[83] These ordinances recognize the impact that stormwater runoff can have on Geneva Lake, require stormwater control plans for new developments, and set criteria for stormwater management during and following new developments. The draft Village comprehensive plan recommends

[81] *City of Lake Geneva Municipal Code, Chapter 78 Utilities, Section 78-247 Storm sewers; stormwater management. https://ecode360.com/14146077#14146079*

[82] *City of Lake Geneva, Wisconsin Comprehensive Plan prepared by Vandewalle & Associates, Inc., amended October 2022. https://www.cityoflakegeneva.gov/DocumentCenter/View/758/Lake-Geneva-Comprehensive-Plan--Amended-10242022-PDF*

[83] *Village of Williams Bay Municipal Code, Part II General Legislation, Chapter 178 Erosion Control and Stormwater Management. https://ecode360.com/34297034#34297034*

facilitating maximum stormwater infiltration by maximizing permeable surface areas, preserving and enhancing environmental corridors, planting native vegetation, enforcing construction site erosion control practices, and installing BMPs, such as rain barrels, rain gardens, vegetated buffer strips, and bioswales.[84] Additionally, the plan recommends developing specific stormwater management standards for small redevelopment projects, which the Village is interested in encouraging.

Stormwater in the Town of Linn is drained using swales, ditches, and culverts but the Town does not have a formal sewer system.[85] The Town comprehensive plan recommends adopting policies that encourage low impact development during and following residential development as well as protecting features that provide groundwater recharge and utilizing native plants as part of the stormwater management strategy.

Older forms of stormwater BMPs are most likely to be found in areas that have been under urbanized land use for longer amounts of time, and can include storm sewers, curb and gutter, and swales. In areas with older stormwater infrastructure, noting the locations of outfalls that discharge stormwater with limited treatment directly into Geneva Lake, and which could be contributing pollutants including sediments into nearshore areas of the Lake, would be beneficial for monitoring. Such outfalls might be good candidates for modification or improvement to reduce stormwater pollutants from entering the Lake. Areas that have been more recently developed with higher probability of updated infrastructure and BMPs types. These BMPs include the aforementioned practices, but wet and dry stormwater detention basins are much more prevalent among new developments. These basins are designed to capture the stormwater runoff water and release it at a reduced rate. Wet basins allow the total suspended solids particles, nutrients, and associated materials to settle out. Dry basins generally provide little control of nonpoint source pollution, because they have no permanent pool for settling and subsequent storage of particulate pollutants. Stormwater is diverted into these basins prior to discharging into the surface water of the Lake or local tributaries and streams within the Geneva Lake system.

[84] *Village of Williams Bay Draft 2023 Comprehensive Plan prepared by Vandewalle & Associates, Inc., February 2023. https://www.williamsbay.org/sites/g/files/vyhlif7306/f/uploads/williams_bay_comprehensive_plan_draft_3_2.1.23.pdf*

[85] *Town of Linn, Walworth County, Wisconsin Comp Plan 2040, prepared by Community Planning & Consulting, LLC, 2019. https://townoflinn.wi.gov/comprehensive-plan/*

Lake Stakeholder Organizations

Geneva Lake is a treasured resource not only for the local community but also visitors across the Region. Consequently, many organizations have a vested interest in protecting the aesthetics, water quality, and ecological integrity of the Lake. An overview of these stakeholders is given below and additionally shown in Table 2.7.

Government

Municipalities

Five municipalities are involved in multiple aspects of lake management: City of Lake Geneva, the Villages of Fontana-on-Geneva-Lake and Williams Bay, and the Towns of Linn and Walworth. Among other responsibilities, this involvement comes through the ownership and management of public boat launches, supporting inter-municipal agencies, maintaining municipal committees addressing piers and harbors, providing drinking and wastewater services, and enforcing stormwater management ordinances. Another central responsibility of the municipalities is authorizing the joint ordinance that regulates boating on Geneva Lake; this ordinance can be revised through the inter-municipal Geneva Lake Use Committee.

Walworth County

Walworth County is an administrative division of local government and provides large-scale oversight to planning efforts as well as execution of those efforts to the lands within it; this includes Geneva Lake and its watershed. As a governmental entity, the County provides resources to groups such as contacts and grant partnerships for the maintenance and improvement of waterbody health. Specifically, the County works with agricultural landowners for the implementation of best management practices in their fields, limiting sediment and fertilizer runoff into surrounding waterbodies.

Geneva Lake Environmental Agency

The Geneva Lake Environmental Agency (GLEA) is an inter-municipal agency formed in 1971 between the City of Lake Geneva, the Villages of Fontana-on-Geneva-Lake and Williams Bay, and the Towns of Linn and Walworth.[86] The GLEA board is comprised of one representative appointed by each municipal government as well as one citizen from each municipality; each municipality has one vote. [87] The GLEA's mission is to protect and improve the water quality, ecological health, and environmental integrity of Geneva Lake

[86] *https://www.gleawi.org/*

[87] *https://www.gleawi.org/_files/ugd/456c61_ff59c9f31a344eb3a42530e5707a8e9f.pdf*

through coordinated, science-based management, research, monitoring, and education. GLEA strives to keep Geneva Lake clean, safe, and resilient by using science to guide action, education to build awareness, and collaboration to protect this shared resource for future generations. As an inter-municipal agency, the GLEA provides information on the lake's ecology to its municipalities and other lake stakeholder groups but has also maintained a role in lake management, particularly regarding invasive species. In recent years, the GLEA has conducted studies of the lake's aquatic plants, nearshore fisheries, zebra mussels, and boating; funded Lake water quality monitoring and studies of lake tributaries; collected water quality samples at public beaches; supported installation of boat cleaning stations at municipal launches; and helped manage the Clean Boats, Clean Waters program at launches.

Geneva Lake Law Enforcement Agency

The Geneva Lake Law Enforcement Agency (GLLEA), also known as the Geneva Lake Police, was formed in 1968 as an inter-municipal agency between the City of Lake Geneva, the Villages of Fontana-on-Geneva-Lake and Williams Bay, and the Towns of Linn and Walworth.[88] These municipalities also voted to establish a joint lake ordinance, which was mostly recently updated in June 2021.[89] The GLLEA is currently staffed by 15 officers, one Sargeant, and one Commander and operates between April and October each year. The WDNR reimburses up to 75 percent of the operating costs.

Linn Sanitary District

The Linn Sanitary District was formed in 1946 and serves residences in the Town of Linn that are not a part of sanitary sewer service areas.[90] Homes within the District are instead serviced by private wells and use decentralized on-site systems for wastewater treatment. As of the Spring of 2024, over 1,360 Private On-Site Wastewater treatment systems (POWTS) have been inspected or reinspected by professional, State licensed inspectors for the identification of any needed replacements or upgrades. The District works to provide implementation and enforcement of these inspections, upgrades and maintenance to systems, and education to communities to ensure ground and drinking water are safe for the residences they serve.

[88] *https://genevalakepolice.com/*

[89] *https://genevalakepolice.com/resource-doc/LAKE%20ORD%20Flyer.pdf*

[90] *https://townoflinn.wi.gov/sanitary-district/*

Non-Profit Organizations

Geneva Lake Conservancy

Originally known as the Committee to Save Geneva Lake, the Geneva Lake Conservancy ("GLC"), formed in 1977 in response to pollutant loading concerns that morphed into a larger effort to protect land surrounding the Lake.[91] The GLC is a 501(c)(3) land trust that protects lands within the Lake watershed and across Walworth County. The GLC completed its first conservation easement in 1986 to prevent subdivision of a lake estate. In recent years, the GLC has managed land preserves, helped fund farm conservation practices, and supported the installation of shoreline buffers through programs like Conservation@Home. The GLC currently holds 20 conservation easements in the Geneva Lake watershed and three properties that combined protect 700 acres. Additionally, the GLC supports and advocates for the protection of open space and natural areas, farmland preservation, and conservation in zoning.

Geneva Lake Association

Originally known at the Geneva Lake Property Owners Association, the GLA formed in 1935 to preserve the environmental integrity of Geneva Lake.[92] The Association is a 501 (c)(3) non-profit organization comprised of a large membership of fee-paying members, which include individual property owners, homeowner associations, and businesses. The Association produces a quarterly newsletter addressing lake topics, helps to coordinate and fund lake management efforts, and provides links to lake information on its website.

Geneva Lake Water Safety Patrol

The Water Safety Patrol is a non-profit organization formed in 1920 to promote safety in Lake recreational activities. The Patrol has employed swimming instructors and lifeguards since its inception and purchased its first patrol boat in 1925. The Patrol currently has six fully-equipped boats manned by trained crew members that are certified in water rescue, first aid, cardiopulmonary resuscitation, and boat handling. Operating its boat patrol between 9 AM and 9 PM in summer, the Patrol helps conduct rescue operations and boat assistance on the lake. Additionally, the Patrol enhances law enforcement by hosting boater safety courses, lifeguard training, and swim lessons.

[91] *https://www.genevalakeconservancy.org/*

[92] *https://genevalakeassoc.org/*

Homeowners Associations

Several homeowners and condominium associations manage the residential neighborhoods surrounding the Lake. The specific duties of groups vary depending on location, size, and organization type, but broad functions include the establishment and enforcement of rules and regulations, the collection of dues, and subsequent allocation of funds for property maintenance and additional association benefits.[93] Further involvement may include consistent outreach to homeowners, including seasonal residents, and management of Lake access amenities. Some associations may apply for WDNR permits for aquatic plant management within their jurisdiction.

Clubs and Marinas

Geneva Lake hosts several exclusive clubs and marinas which provide services to their members in addition to access to clubhouses or facilities. The connection of these groups to the Lake can be dated back to 1874, and club identity is deeply tied to Geneva Lake.[94] Some services these groups provide include anchorage locations, member gatherings, and athletic opportunities (tennis, swimming, golf, and sailing) in and around the Lake. Groups may sponsor events or participate in re-occurring Lake traditions.

Fishing

Fishing groups seek to promote sport fishing on Geneva Lake. The Lake Geneva Fishing Club is a 501(c)(3) non-profit founded in the mid-1960s that aims to connect anglers of the Lake through educational meetings and events.[95] Additionally, various private fishing guides offer species-specific fishing trips for both novice and experienced anglers.

Boat Rentals and Repairs

As a popular recreational location, Geneva Lake offers a wide range of watercraft and repair services. Both motorized and non-motorized watercraft are available for rental or sale, watersport lessons such as skiing or wake surfing are routinely given, and boat repair services are readily available. Some businesses such as

[93] *Many of the homeowners and condominium associations in the Geneva Lake watershed have regularly updated websites which detail their specific duties.*

[94] *https://lgyc.com/*

[95] *http://www.lakegenevafishingclub.com/*

Gordy's Marine offer combinations of the aforementioned amenities.[96] These businesses act as guides and provide safety and security services to recreational Lake users.

Libraries, Museums, and Schools

Educational institutions around the Lake include Badger High School in the City of Lake Geneva, Williams Bay High School in the Village of Williams Bay, and Big Foot High School in the Village of Walworth. Other libraries, museums, and educational programs provide community outreach, information on the area's history, and opportunities for the improvement of Geneva Lake.[97]

Camps and Resorts

Year-round and seasonal retreat locations utilize the Lake as gathering place for youth, adults, people with disabilities, and those who do not have regular access to greenspace, amongst others. Camps have been established on the Lake for over a century, and now several actively work to serve participants through outdoor recreational opportunities.[98] Through swimming, hiking, and scenic views, these camps and resorts usher generations through their camps to recreate and enjoy the Lake.

Ecotourism

Several stakeholders work together to bring tourism to the area and make the Lake a desired destination. The City of Lake Geneva was ranked as one of the best small towns in the Midwest in 2025 for its broad array of offerings to visitors.[99] Geneva Lake is both provided for and used by these groups and is central for tourism in the area. In 2025, Walworth County ranked 6th in the State of Wisconsin for total tourism dollars spent, with Geneva Lake comprising 70 percent of the County's total tourism revenue. The Abbey, a marina and resort located on Geneva Lake, was the 7th largest employer in the County.[100] Member-based recreation groups, public outdoor recreation spaces, fishing, watercraft sales and rentals, camps, and organized Lake outings all depend on the use of Geneva Lake for their operation. As these businesses utilize the Lake daily,

[96] *https://www.gordysboats.com/*

[97] *GLAS Education offers programs in water quality monitoring and reduction of light pollution in Geneva Lake.*

[98] *The Norman Barr Camp located in the Village of Williams Bay was established in 1909.*

[99] *https://www.msn.com/en-us/travel/tripideas/this-wisconsin-city-is-among-the-best-small-towns-in-the-midwest-usa-today-says/ar-AA1CC6Dy?ocid=socialshare*

[100] *https://www.co.walworth.wi.us/ArchiveCenter/ViewFile/Item/415*

actively or passively, incorporating environmentally friendly practices into their operation can make a substantial impact on the health of the Lake. These practices, referred to as 'ecotourism', focus on the implementation of environmentally responsible travel. A brief discussion of applicable practices that can be implemented on Geneva Lake are discussed below, and shown in detail in Table 2.8.

Tourism agencies such as Visit Lake Geneva and the Walworth County Visitors Bureau focus on planning and booking travel to the Geneva Lake area. As an advertising agency, using their contacts and audience reach to highlight eco-conscious business practices on the Lake can in turn communicate to the public how the businesses of Geneva Lake strive to maintain the Lake's quality. Additionally, internal outreach to gauge interest of business partners for this promotion may bring to light current sustainable practices being employed on the Lake that may be unknown to other groups, helping to foster collaboration and implementation of practices for others. Membership-based recreational groups like the Abbey Marina or the Lake Geneva Country Club offer exclusive benefits which include riparian property and nearby Lake recreation. Implementing best management practices on their shorelines by providing a buffer zone for water storage and energy dispersion may include methods like deep-rooted native plantings or other means.

In public outdoor recreation areas like public beaches or parks, installing signage for litter pickup, maintaining dog waste pickup stations, or bagging grass clippings as turfgrass is mowed to prevent the grass clippings being blown into the water can minimize the impact of high recreational usage in the area. Camps and other organized outings (e.g., recreation departments and seasonal camp experiences) can incorporate stewardship components in addition to safety and general instructions before taking participants out on the Lake; ensure associated swimming areas are properly marked for Slow, No Wake; and connect with Lake improvement groups for volunteer opportunities, workshops, cleanups, or educational seminars.

Fishing groups, along with boat sales and rentals businesses (e.g., fishing guide services, fishing clubs, marine rentals, and cruise lines) can offer boating etiquette handouts or postings on their associated boats; utilize electric or hybrid motors; specify the importance of Slow, No Wake to limit shoreline disturbance when touring lakefront properties; confirm onboard waste is collected and disposed of; and use alternatives to lead bobbers.

Some ecotourism practices can be applied to several types of tourism groups, such as including permeable pavement in parking lots or other paved areas to slow runoff into the Lake. However, not all ecotourism practices may be applicable. As such, ecotourism practices can be implemented or tailored on a case-by-case basis. The collective implementation of these practices over time can produce compounding benefits to the Lake and its users. Inclusion of the tourism industry is essential in ensuring the Lake to be a desired destination for generations.

2.4 WATER QUALITY

Waterbody users, the general public, and regulatory agencies are all interested in water quality for a variety of reasons. Most individuals classify water quality by visual cues such as water clarity, general appearance, and the amount of visible floating debris, aquatic plants, and algae. For example, algal blooms or cloudy water can lead an observer to conclude that lake water is "dirty". Such visual cues are examples of perceived water quality. In contrast, to accurately classify and track water quality, regulators and lake managers generally base water quality judgments based on measurements of quantifiable physical, chemical, and sometimes biological factors defined through carefully designed and executed sampling protocol. These data are often collected by local volunteers, lake managers, consultants, and regulators. Lake managers then analyze resultant data for values and trends that influence, or are indicators of, water quality. Changes in water quality over time can be a powerful tool to help make sound lake management decisions.

Geneva Lake residents and Lake users have expressed concern that pollutants entering the Lake from various sources and are concerned that this may compromise Lake water quality over time. These concerns typically are related to fertilizers and pesticides leaching from shoreline properties, fertilizer and sediment washing into the lake from urban and agricultural properties, a wide variety of substances carried directly to the Lake with rainfall and snowmelt. Additionally, specific concern has arisen over sediment, nutrients, and other pollutants contributed to the lake by Bigfoot Creek and other tributaries. Lake resident/user concern about aquatic plant growth and nonnative plants underscore the stated interest in water quality given that water quality profoundly influences the overall fertility of the Lake and its ability to support aquatic plants and algae abundance.

Background

Several factors and lake characteristics lend context to water quality analyses and should be considered when reviewing data sets. Such context can help identify past, current, and/or future water quality problems, agents that cause these problems, and the ability of the lake to maintain itself of recover. Examples of such factors are listed below.

- **Lake tributary area and land use.** Lakes with large tributary streams commonly receive larger sediment and nutrient loads than lakes that are fed primarily by precipitation or groundwater. The type of land use in the watershed greatly effects the pollutant loads carried by tributary streams.
- **Lake type**. The shape and hydrology of a lake can have important implications for water quality conditions as well as the water quality standards applied to the Lake.[101] As described in Section 2.2, Geneva Lake is considered a headwater or drained lake meaning that its tributary streams do not contribute most of its water, but an outlet stream is the main source of water exiting the lake. Instead of tributary streams, precipitation or groundwater are typically the main sources of water to the lake, which can result in higher water quality conditions if these sources, particularly groundwater, are not polluted. Geneva Lake is also considered a "two-story" lake, meaning that the Lake is deep enough to maintain a layer of cold, well-oxygenated water in deeper areas of the Lake. Two-story lakes and their significance are discussed in greater detail later in this section.

- **Temporal and spatial water quality fluctuations.** While water quality samples are typically collected at set times and locations, they may not represent water quality everywhere in the lake at any given point in time. Furthermore, they may only reflect transient conditions occurring during a relatively brief, discrete, time period (e.g., daytime versus nighttime). To determine which water quality management efforts can help achieve goals, it is important to understand current lake conditions, contrast past values, and estimate pre-settlement and future water quality. To do this, critical parameters) are measured, simulated, and tracked over time to evaluate how water quality changes during each year and over long series of annual sampling. Water quality is also likely to vary within a lake during a given time period. For example, water quality values from various depths may differ. This data is contrasted to evaluate in-lake distribution, circulation, and

[101] Wisconsin Consolidated Assessment and Listing Methodology (WisCALM), *Wisconsin Department of Natural Resources, 2024*.

physical/chemical/biological processes. Data sets suggesting deteriorating conditions can help identify pollutants and issues that should be targeted for management action.

- **A lake's hydraulic residence time.** Hydraulic residence time refers to the average length of time needed to replace the lake's entire water volume.[102] Hydraulic residence time helps determine how quickly pollution problems can be resolved. For example, if lake retention times are short, pollutants are flushed from a lake fairly quickly. In such cases, management efforts can likely focus on pollutant and nutrient loads contributed to the lake from the watershed. In contrast, lakes with long retention times tend to accumulate nutrients and pollutants. These can eventually become concentrated in bottom sediments. In this case, in addition to preventing external pollution, it also may be necessary to employ in-lake water quality management efforts.

- **Whether the lake stratifies and when the lake mixes.** Stratification refers to a state in which the temperature difference (and associated density difference) between the surface waters of a lake (the *epilimnion*) and the deep waters of the lake (the *hypolimnion*) is great enough to form thermal layers that impede mixing of gases and pollutants between the two layers (see Figure 2.9). If a lake stratifies, oxygen-rich surface water in contact with the atmosphere does not freely mix with water in deeper portions of the lake. Therefore, the deeper hypolimnetic water cannot exchange gases with the atmosphere. Metabolic processes continue to consume oxygen in the hypolimnion. If oxygen demands are high (such as in an enriched lake), and/or if the volume of deep isolated hypolimnetic water is small (limiting oxygen storage potential), oxygen concentrations in water in deep portions of lakes can become extremely low (hypoxic) for periods of time. Water that is completely devoid of oxygen is termed anoxic. While some lakes remain permanently stratified, stratification in most Wisconsin lakes breaks down at least twice per year (once in spring and once in fall) in response to changing seasons and ambient weather conditions.

  A lake must be relatively deep to create sufficient temperature differences between surface and bottom waters for the lake to stratify. In general, lakes in Southeastern Wisconsin less than 15 feet deep are unlikely to stratify, whereas lakes with depths greater than 20 feet are likely to stratify. A

[102] *The term "flushing rate" is also commonly used to describe the amount of time runoff takes to replace one lake volume. Flushing rate is the mathematic reciprocal of hydraulic residence time. Therefore, while retention time is expressed in years and has units of time, flushing rate is typically expressed as the number of times lake water is completely replaced by runoff in one year, and is therefore a rate (units/time).*

lake's propensity to stratify is heavily influenced by the lake's shape, size, orientation, landscape position, surrounding vegetation, through flow, water sources, and a host of other factors. Depth to the *thermocline* (the transition layer between the epilimnion and hypolimnion, sometimes also called the *metalimnion*) can range from less than 10 feet to well over 20 feet in typical Southeastern Wisconsin lakes.

Most deep lakes in the Region stratify sometime during mid to late spring, with a short (usually less than a week) period of whole-lake water circulation and mixing (turnover) that takes place once during spring and once again in fall (see Figure 2.9). At turnover, the lake's temperature is uniform from the surface to the bottom. Lakes that stratify and turn over in the spring and fall are termed "dimictic." Certain lakes that weakly stratify and are shaped and oriented to be exposed to wind may also mix during the summer. Lakes can also weakly stratify in winter when warmer, denser water is found in the deeper portions of the lake.

It is important to determine if lakes stratify and periodically mix. When isolated from the atmosphere, deep water may develop water quality characteristics very different than near surface water and may contain high concentrations of nutrients, little oxygen, and in some cases may have elevated concentrations of sediment and other pollutants. These substances, accumulated in deep water over protracted periods of time, can suddenly mix into the entire water column during the turnover period, causing water quality and plant management problems. For example, abundant nutrients from the hereto isolated deep portions of a lake can mix into near-surface water which in turn can fuel nuisance-level algae and plant growth.

- **A lake's current and past trophic status.** Lakes are commonly classified according to their degree of nutrient enrichment, or trophic status. The ability of lakes to support a variety of recreational activities, healthy fish, and other aquatic life communities is often correlated with the lake's degree of nutrient enrichment. Three terms are generally used to describe the trophic status of a lake: oligotrophic (nutrient poor), mesotrophic (moderately fertile), and eutrophic (nutrient rich) (see Figure 2.10). Each of these states can happen naturally. Lakes tend to shift to a more nutrient-rich state over time, a progression often referred to as "aging." However, if a lake rapidly shifts to a more eutrophic state, human-induced pollution is often responsible for this change. Under severe pollution and highly enriched conditions, a lake enters the "hyper-eutrophic" condition. Hyper-eutrophic conditions do not commonly occur naturally and are nearly always related to human pollution sources.

- **Whether internal loading is occurring.** Internal loading refers to release of phosphorus stored in a lake's bottom sediment that occurs under low oxygen conditions associated with lake stratification. Phosphorus is typically not particularly soluble and often adheres to particles that settle to the lake bottom. When organic detritus and sediment settle to the lake bottom, decomposer bacteria break down the organic substances, a process that consumes oxygen. If lake-bottom waters become devoid of oxygen, the activity of certain decomposer bacteria, together with certain geochemical reactions that occur only in the absence of oxygen, can allow phosphorus from plant remains and lake-bottom sediment to dissolve into the water column. This allows phosphorus that is otherwise trapped in deep lake-bottom sediment to be released into lake water. This released phosphorus can mix into the water column during the next turnover period fueling plant and algae growth. In most lakes, phosphorus is the nutrient controlling overall plant and algal growth, and additional phosphorus can lead to increased plant and algal growth. If internal loading is a primary component of a lake's phosphorus budget, water quality management may focus on in-lake phosphorus management efforts in addition to preventing polluted runoff from entering the lake.

Several analyses are commonly used to quantitatively measure water quality. Common water quality indicators include water clarity, water temperature and the concentrations of nitrogen, phosphorus, chlorophyll-*a*, and dissolved oxygen. These parameters may interact with one another in a variety of ways. For example, certain sources of pollution tend to increase a lake's phosphorus concentration, diminish water clarity (due to algal growth in the water column), and increase abundance of chlorophyll-*a* (a measure of algae content). In addition to these basic parameters, several other analyses can help lake managers quantify lake health. For example, the abundance of the bacteria *Escherichia coli*, commonly known as *E. coli*, is often measured to evaluate if water is safe for swimming while chloride concentrations are an indicator of the overall amount of human-derived pollution entering a lake.[103] To develop and judge the success of a plan that helps maintain and improve water quality, key water-quality indices must be regularly

[103] Chloride is used as an indicator of human-derived pollution because it is usually naturally present throughout the Region at low concentrations. Chloride is a "conservative pollutant" meaning that it remains in the environment once released and is not attenuated by natural processes other than dilution. High chloride concentrations may result from road deicer runoff, fertilizer application, and private onsite wastewater treatment systems that discharge to groundwater that in turn provides baseflow to streams and lakes, and a long list of other human-derived sources.

measured over extended periods of time. These measurements are compared against the WDNR water quality standards published in the Wisconsin Consolidated Assessment and Listing Methodology (WisCALM) when waterbodies are assessed for impairment.[104]

Geneva Lake

This section will describe conditions and trends across several facets of Geneva Lake's water quality. As one of the largest and deepest lakes in Wisconsin, Geneva Lake has been the subject of many studies and data collection efforts. Some records, such as ice-on and ice-off dates, have been collected on the lake for over a century (see climate discussion in Section 2.2). The earliest known water quality data for Geneva Lake dates to the early 1900s, when Edward Birge and Chancey Juday, widely-recognized pioneering lake researchers from the University of Wisconsin, collected basic information on the Lake.[105] The 1969 Lake Use Report from the WDNR provides another early comprehensive dataset for the Lake, with measurements of temperature, dissolved oxygen, nutrients, chloride, alkalinity, and other parameters of interest. Since that time, the GLEA, WDNR, and the USGS, among other partners, have supported a long-running water quality monitoring program for the Lake. Additionally, the GLEA monitors *E. coli* abundance at public beaches on the Lake to ensure safe swimming conditions. This study will focus on long-term trends and recent water quality data collected since the previous management plan published in 2008. Water quality monitoring sites and areas discussed in this Section are presented in Map 2.20.

Water Temperature and Dissolved Oxygen

As discussed in the previous edition of the lake management plan, Geneva Lake is a dimictic lake meaning it completely mixes twice a year and is subject to thermal stratification during summer. Consequently, temperature and dissolved oxygen concentrations vary substantially with lake depth during the stratified period in summer through early fall. The epilimnion (surface waters) are typically well-mixed and have consistent temperature and dissolved oxygen concentrations. The thermocline marks the depths where water temperature rapidly decreases with increasing water depth while the hypolimnion are the deepest depths where temperatures are fairly consistently cold during summer months.

[104] Wisconsin Consolidated Assessment and Listing Methodology (WisCALM), *Wisconsin Department of Natural Resources, 2024*.

[105] *E.A. Birge and C. Juday*, The Inland Lakes of Wisconsin: The Dissolved Gases and their Biological Significance, *Wisconsin Geological and Natural History Survey Bulletin No. XXII, 1911*.

Commission staff compiled temperature and dissolved oxygen (DO) data for Geneva Lake spanning several decades. Temperature profiles measured between 2011 and 2023 are illustrated on Figure 2.11. These temperature profiles exhibit the Lake's thermal stratification beginning in June and persisting until early November in most years. By late November, the lake turns over and becomes completely mixed with nearly uniform temperatures throughout all recorded water depths. This period of stratification has extended several weeks since the 1976-1977 monitoring period of the first Geneva Lake management plan, which reported that fall turnover occurs on the Lake in mid-October. This lengthening of the stratified period could have significant impacts on water quality, such as increasing the frequency of algal blooms, limiting available habitat for sensitive fish species such as cisco and trout, and increasing phosphorus contributions from internal loading. These water quality impacts will be discussed in greater detail later in this Section.

As shown in these profiles and as reported in the previous edition of this plan, the epilimnion extends from the water surface to approximately 30 feet in depth while the thermocline occupies the depths between approximately 30 and 55 feet. The hypolimnion, which occupies the water depths greater than approximately 55 feet, had average summer temperatures between 40 and 48°F which are suitable for supporting coldwater fish species such as cisco (*Coregonus artedi*) and lake trout.

Maximum surface temperatures are an important factor of water quality, as excessively warm water temperatures can be stressful or even lethal to aquatic life. Consequently, the WDNR has established acute temperature criteria by month for streams and lakes.[106] The previous editions of this plan reported maximum summer temperatures of up to 79°F between 1976 and 1977 and up to 81°F between 1988 and 2004. The maximum temperature recorded between 2011 and 2023 was 80.2°F, indicating that the maximum surface water temperatures the Lake experiences have only slightly increased within the past 50 years. July and August are the warmest months of the year with average epilimnion temperatures of 74.7 and 75.9°F, respectively, as measured between 2011 and 2023. The average and maximum temperatures are substantially below the WDNR acute temperature criteria of 87°F for southern lakes in July and August and are also markedly below other large, deep lakes within southeastern Wisconsin.

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. DO is generally higher at the surface of a lake where there is an interchange between the water

[106] *WisCALM, 2026,* op. cit.

and atmosphere, stirring by wind action (which aids in the process of diffusion of atmospheric oxygen into the surface waters at the air-water interface), and production of oxygen by plant photosynthesis. However, if a lake thermally stratifies during summer, the thermocline prevents oxygen-rich surface waters from freely mixing with water in deeper portions of the lake. Meanwhile, metabolic processes that consume oxygen continue to occur in the hypolimnion throughout the summer. If oxygen demands in the hypolimnion during this time are high (such as in a nutrient-rich lake) or if the volume of isolated hypolimnetic water is small, oxygen levels in the deep portions of lakes generally begin to decline as summer wears on. A minimum DO concentration of 5 mg/l is considered necessary for survival of most species of fish while 6 mg/l is required for cisco, which has a well-documented population in Geneva Lake (see Section 2.7, "Fisheries and Aquatic Animals"). In many Southeastern Wisconsin lakes, as summer progresses, oxygen concentration in water below the thermocline may be reduced to less than 1.0 mg/l—a condition known as anoxia. Fortunately for fish and other oxygen-dependent organisms in the lake, oxygenated surface waters are able to mix throughout all depths of the lake when the thermocline breaks down during the fall and spring overturns.

Comparing DO profiles to the seasonal temperature profiles reveals the close relationship between DO and temperature, as governed by thermal stratification. The deepest portions of Geneva Lake commonly have less oxygen than surface water in all seasons, particularly during summer and winter stratification. Deep water anoxia is a common occurrence in stratified lakes and has been observed in approximately half of all Wisconsin lakes that are deep enough to thermally stratify.[107] By June, summer stratification develops and results in decreasing oxygen levels below 55 feet depth (the level of the thermocline) with anoxic conditions at the 120-foot depth and below (see Figure 2.12). Anoxia conditions are closest to the surface in September with depths as shallow as 50 feet in September 2012 but between 100 and 120 feet most other years since 2010. During these periods, anoxic waters cover about 450 acres of the Lake's bottom.

Fall turnover, which occurs in November in most years, naturally restores the supply of oxygen to the bottom water as the Lake becomes fully mixed. When mixed, oxygen concentrations vary little with depth and the Lake is capable of supporting aquatic life present at essentially all depths. However, winter stratification can also cause hypolimnetic anoxia to establish, which is more common during the years when heavy snow covers the ice, reducing the degree of light penetration and reducing algal photosynthesis that takes place

[107] Lillie and Mason, 1983, *op. cit.*

under the ice. At the end of the winter, DO concentrations in the bottom waters of the Lake have been restored during the period of spring turnover as the Lake is usually fully mixed by April.

Hypolimnetic anoxia can affect the concentrations of nutrients, such as phosphorus, in a lake's waters. Phosphorus is typically not particularly soluble in water and often adheres to particles that settle to the lake-bottom. When bottom waters become void of oxygen, the activities of decomposer bacteria in the bottom sediments, together with certain geochemical reactions that occur only in the complete absence of oxygen, can allow phosphorus in plant remains and lake-bottom sediment to dissolve into the water column. This allows phosphorus that is otherwise trapped in deep lake-bottom sediment to be released into lake water. This release of phosphorus is referred to as "internal loading". The released phosphorus can then mix into the water column during the next turnover period, fueling plant and algae growth. Since Geneva Lake does stratify, internal loading of phosphorus is a potential concern. For information on current internal loading conditions, refer to the internal loading discussion in Section 2.5, "Pollutant Loads".

Hypolimnetic anoxia can also affect fish populations. Depleted oxygen levels in the hypolimnion cause fish to move upward, nearer to the surface of the lakes, where higher DO concentrations exist. This migration, when combined with temperature, can select against some fish species that prefer the cooler water temperatures that generally prevail in the lower portions of the lakes. When there is insufficient oxygen at these depths, these fish are susceptible to summer kills, or, alternatively, are driven into the warmer water portions of the lake where their condition and competitive success may be severely impaired. In 2012, which had particularly low dissolved oxygen concentrations, DO concentrations were at or below the recommended minimum 5 mg/l level necessary to support many fish species at depths of 35 feet and below in August and these conditions continued through September.

Cisco Oxythermal Habitat

Cisco (*Coregonus artedi*) are a native coldwater fish that inhabit deep lakes in Wisconsin. As described more fully in Section 2.7, "Fisheries and Aquatic Animals," cisco are a preferred prey fish for large gamefish and lakes with dense population of cisco, such as Geneva Lake, often have higher growth rates of gamefish like walleye, northern pike, lake trout, and muskellunge. This species requires cold, highly-oxygenated waters for its survival with summer water temperatures below 73°F and dissolved oxygen concentrations of at least

6 mg/l.[108] As summer stratification progress, the lake epilimnion typically becomes too warm for cisco in many lakes and thus these fish must take refuge in cooler, deeper, well-oxygenated waters. In southeastern Wisconsin, only very deep lakes support a layer of cold, well-oxygenated water that can sustain cisco populations; these lakes are referred to as "two-story" lakes (see Figure 2.13). Commission staff evaluated the thickness of waters with suitable oxythermal habitat, i.e. below 73°F and above 6 mg/l, in Geneva Lake.

July, August, and September had epilimnion temperatures that routinely exceeded 73°F, limiting available cisco habitat in the uppermost layers of the Lake during these months (see Figure 2.11). However, aside from an approximately ten foot layer of lower concentrations at the top of the thermocline, July and August maintained dissolved oxygen concentrations of at least 6 mg/l down to water depths of at least 70 feet. Consequently, the Lake still provides significant refuge from the elevated water temperatures in the deeper waters during these months. In September, the dissolved oxygen concentrations in the deeper waters are significantly diminished, with years like September 2022 where dissolved oxygen concentrations of at least 6 mg/l are only maintained to a depth of approximately 45 feet (see Figure 2.12). Maximum temperatures in September rarely exceed 73°F, so the epilimnion becomes a suitable habitat for cisco when these deeper waters become too oxygen-limited. Based on this evaluation and recent WDNR fishery survey data (see Section 2.7, "Fisheries and Aquatic Animals"), the Lake still supports significant oxythermal habitat for cisco. However, as air and surface water temperatures continue to warm with climate change, this habit could become increasingly limited, particularly during September.

pH and Acidity

The acidity of water is measured using the pH scale. The pH scale is a logarithmic measure of hydrogen ion (H+) concentration on a scale of 0 to 14 Standard Units (SU), with 7.0 indicating neutrality. Water with pH values lower than 7.0 SU has higher hydrogen ions concentrations and is more acidic, while water with pH values higher than 7.0 SU has lower hydrogen ion concentrations and is less acidic. Since the scale is logarithmic, each 1.0 pH change reflects a tenfold change in hydrogen ion concentration, e.g., a pH of 4 is ten times more acidic than a pH of 5 and a hundred times more acidic that a pH of 6. In Wisconsin lakes,

[108] Evaluation of oxythermal metrics and benchmarks for the protection of cisco (Coregonus artedi) habitat quality and quantity in Wisconsin lakes John Lyons, Timothy P. Parks, Kristi L. Minahan, and Aaron S. Ruesch, Can. J. Fish. Aquat. Sci. 00: 1–9 (0000)

pH can range anywhere from 4.5 in some acid-bog lakes to 8.4 in hard water, marl lakes.[109] Many chemical and biological processes are affected by pH, as are the solubility and availability of many substances. Different organisms can tolerate different ranges of pH, with most preferring ranges between about 6.5 and 8.0 SU. Although moderately acidic (slightly below a pH of 7) does not usually harm fish, as pH drops to 6.5 or lower, some species can be adversely affected, especially during spawning. For example, at a pH of 6.5, walleye spawning can be inhibited; at a pH of 5.8, lake trout spawning is inhibited; and at a pH of 5.5, smallmouth bass disappear.[110] As pH continues lower, walleye, northern pike and other popular sport fishes gradually disappear and a pH of 3.0 is toxic to all fish.[111] In addition, many metals are more soluble in water with low pH than they are in water with high pH. Thus, toxicity of many substances for fish and other aquatic organisms can be affected by pH. Under low pH conditions, toxic metals, such as aluminum, zinc and mercury, can be released from lake sediment if present. At a pH of 5.0, aluminum is at its most poisonous, precipitating onto the gills of the fish in the form of aluminum hydroxide.[112]

Lakes have natural and man-made sources of acidity. Peat-bog lakes are naturally acidic due to the natural release of organic acids during decomposition; many such lakes are without fish[113]. Because of diffusion of carbon dioxide into water and associated chemical reactions, rainfall (in areas that are not impacted by air pollution) has a pH of about 5.6 SU; the pH of rainfall in areas where air quality is affected by oxides of nitrogen or sulfur tends to be lower. The mineral content of the soil and bedrock underlying a waterbody also has a strong influence on the waterbody's pH. Most lakes in Southeastern Wisconsin tend to be alkaline with a pH between 8.0 and 9.0 SU.[114] Pollutants contained in discharges from point sources and in stormwater runoff can also affect a waterbody's pH. Further, photosynthesis by aquatic plants, phytoplankton, and algae can cause pH variations both on a daily and seasonal basis.

Measured pH values in Geneva Lake generally range between 7.9 and 8.4 with a median of 8.2 standard units, indicating that the Lake water is alkaline. There has been essentially no change in pH over time in the

[109] *Wisconsin Department of Natural Resources, Byron Shaw, Christine Mechenich, and Lowell Klessig,* Understanding Lake Data*: www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/shoreland/background/understanding%20lake%20data.pdf*
[110] *Ibid.*
[111] *Ibid.*
[112] *www.air-quality.org.uk/13.php.*
[113] *95 T. Hellström, "Acidification in Lakes," In L. Bengtsson, R.W. Herschy, R.W. Fairbridge (eds.)* Encyclopedia of Lakes and Reservoirs*, 2012.*
[114] *Lillie and Mason, 1983, op. cit.*

Lake. As discussed in previous editions of the lake management plan, the pH values for Geneva are within the range of values commonly observed in lakes in southeastern Wisconsin. Since Geneva Lake has a relatively high alkalinity or buffering capacity, the Lake is considered to not be susceptible to the harmful effects of acidic deposition.

Alkalinity and Hardness

Alkalinity is a measure of the capacity of a lake to absorb and neutralize acids, known as "buffering." The alkalinity of a lake depends on the levels of bicarbonate, carbonate, and hydroxide ions present in the water. Lakes in Southeastern Wisconsin typically have a high alkalinity because of the types of soils and underlying bedrock in the Region's watersheds. In contrast, water hardness is a measure of the multivalent metallic ion concentrations, such as those of calcium and magnesium, present in a lake. Hardness is usually reported as an equivalent concentration of calcium carbonate ($CaCO_3$), measured in mg/l. If a lake receives groundwater through rock layers containing calcite and dolomite (both are limestone materials), the lake's alkalinity and hardness will be high. Soft water lakes have calcium carbonate levels less than 60 mg/l; hard water lakes contain levels over 120 mg/l.

Geneva Lake may be classified as a hardwater alkaline lake, with an median alkalinity of 188.5 mg/l and a median hardness of 227 mg/l.[115,116] These measurements are within the normal range of hardwater lakes in Southeastern Wisconsin, which constitute essentially all large lakes within the Region.[117] Total alkalinity is generally stable in the Lake as alkalinity measurements reported between 1968 and 1975 averaged 186 mg/l. However, total hardness appears to have decreased from the measurements reported between 1969 and 1972 (average of 243 mg/l) to those reported in the 2008 lake management plan (average of 220 mg/l) before rebounding to the most recently reported concentrations of 236 mg/l.[118] Given that hardness likely reflects groundwater inputs to the Lake, this decrease may be associated with a wetter period where precipitation contributions were a more significant portion of the lake's hydrologic budget and consequently groundwater contributions were a less significant input to the Lake.

[115] *SEWRPC Community Assistance Planning Report No. 58, 2nd Edition,* op. cit.

[116] *Ibid.*

[117] *Ibid.*

[118] *Ibid.*

Specific Conductance

Specific conductance is a measure of the ability of a liquid, such as lake water, to conduct electricity, standardized at a specific temperature (25°C). This ability is greatly dependent on the concentration of dissolved solids in the water: as the amount of dissolved solids increases, the specific conductance increases. Specific conductance is often useful as an indication of possible pollution of a lake's waters. Freshwater lakes, especially those in watersheds overlaying carbonate formations like dolomite, commonly have a specific conductance in the range of 10 to 1,000 microSiemens per centimeter (μS/cm @ 25ºC). Specific conductance measurements exceeding 1,000 μS/cm may be an indication of surface pollutants, particularly road salt and other de-icing agents.[119] During periods of thermal stratification, specific conductance can dramatically increase at the lake bottom due to an accumulation of dissolved materials trapped in the hypolimnion. Such a condition can lead to a significant concentration gradient, with higher conductance measurements in the deeper waters and lower conductance measurements in the surface waters; these gradients are a consequence of the "internal loading" phenomenon described previously.

Specific conductance profiles with water depth for Geneva Lake between 2010 and 2023 are illustrated on Figure 2.14. These measurements reflect the lake stratification pattern, with uniform specific conductance measurements during lake turnover in spring and fall and increasing conductance with depth while the lake is stratified in summer. This increase is most notable during August, when the conductance sharply increases at the top of the thermocline, and is indicates higher concentrations of ions in the thermocline and hypolimnion than the epilimnion. Another notable pattern in these profiles is that the specific conductance each month is increasing almost annually with the April 2010 profile averaging 530 μS/cm @ 25ºC while the April 2022 profile averaged 555 μS/cm @ 25ºC. In comparison, the specific conductance of the Lake in 1960 was 394 μS/cm @ 25ºC. These annual increases are reflective of increasing ion concentrations year-over-year in Geneva Lake, which Commission staff expect is related to increasing chloride concentrations in the Lake. However, as discussed earlier in this Section, concentrations of calcium, magnesium, and total hardness have also slightly increased in the Lake since 2000 and thus the higher specific conductance measurements may also be reflective of these ions.

[119] 4 Deborah Chapman, Water Quality Assessments, 2nd Edition, E&FN Spon, 1996.

Chloride

Humans use chloride bearing materials for a multitude of purposes, such as road salt, water softening, industrial processes, agricultural nutrients and pesticides, pharmaceuticals, petroleum products, and a host of other substances in common use by modern society. As such, chloride concentrations are normally associated with human-derived pollutant concentrations and are, therefore, a good indicator of the overall level of human activity/potential impact and possibly the overall health of a water body. The most important anthropogenic source of chlorides to Geneva Lake is believed to be the salts used on roads for winter snow and ice control but water softeners from septic systems around the Lake.[120]

Under natural conditions, surface water in Southeastern Wisconsin contains very low concentrations of chloride. Studies completed in Waukesha County lakes during the early 1900s reported concentrations of three to four mg/l of chloride; in fact, lakes in Southeastern Wisconsin had the lowest levels of chlorides statewide.[121] Most Wisconsin lakes saw little increase in chloride concentrations until the 1960s, but a rapid increase thereafter with the increased use of road deicers and chemical fertilizers within the Region. Geneva Lake was first sampled for chloride in 1907 with concentrations ranging from 3.5 to 5 mg/l and not sampled again until May 1960 with a concentration of 5.7 mg/l.[122] As in many southeastern Wisconsin lakes, chloride concentrations have steadily increased since the 1960 measurement, with measurements in April 2025 of 55.7 and 57.1 mg/l (see Figure 2.15).[123] Studies have indicated biological impacts at several trophic levels from chloride concentrations as low as 35 mg/l, where impacts have been documented for diatoms, fish, mussels, and zooplankton.[124] This steady increase in concentrations is a concerning trend for the lake health; recommendations to reduce chloride loads to the Lake are discussed in Chapter 3.

[120]*The major sources of chlorides to lakes in the Southeastern Wisconsin Region include both road salt applications during winter months and salts discharged from water softeners.*

[121]Lillie and Mason, 1983, *op. cit*.

[122] *Birge and Juday,* 1911, op. cit.

[123] *Geneva Lake was a study lake for the Commission's Chloride Impact Study and the GLEA has funded regular chloride measurements through a contract with the USGS.*

[124] *SEWRPC Technical Report No. 62,* Impacts of Chloride on the Natural and Built Environment*, April 2024*.

Water Clarity

One of the three major determinants of trophic status is water clarity. Water clarity, or transparency, provides an indication of overall water quality - the greater the clarity, the better the water quality. Clarity may decrease because of turbidity caused by:

- High concentrations of small, aquatic organisms, such as algae and zooplankton
- Suspended sediment and/or inorganic particles
- Color caused by high concentrations of dissolved organic substances (e.g., tannins that stain water of bog lakes in northern Wisconsin)

In most Southeastern Wisconsin lakes, water clarity is influenced by the abundance of algae and suspended sediment. Water clarity generally varies throughout the year as algal populations increase and decrease in response to changes in lake temperature, sunlight, and nutrient availability. Secchi depth is often highest during winter, indicating high water clarity, and lowest during summer when biological activity is most active Clarity is measured using a Secchi disk, a black-and-white, eight-inch-diameter disk. This disk is lowered into the water until it is no longer visible, at which point the depth is recorded, and then it is raised until visible again, when depth is recorded again. The average of these depths is called the "secchi depth."

Water clarity has substantially increased since 1988, when secchi depth averaged 12.7 feet, to current conditions with an average secchi depth of 36.9 feet in 2024 (see Figure 2.16). These significant increases in clarity are observed in both the eastern and western basins of the Lake, with reported secchi depths of 45.9 and 45.6 feet, respectively, in June 2025. Each month with sufficient observations exhibits increases in clarity over time, but the most notable increases occur in April (24 foot clarity increase between 1989 and 2025) and June (28 foot increase between 1988 and 2025). Across all samples, clarity varies seasonally, with the average highest clarities reported during winter measurements (exceeding 19 feet) and the lowest average clarity in August (11.7 feet).

Many lakes in southeastern Wisconsin, including Geneva Lake, have populations of non-native zebra mussels (*Dreissena polymorpha*). These non-native mussels are prolific filter feeders and thus can improve water clarity by removing particulate matter through filter-feeding. Zebra mussels may be influencing water clarity in the Lakes, but that hypothesis has not been directly tested. As discussed later in this chapter, Geneva Lake is the only inland lake in Wisconsin with a verified population of quagga mussels (*Dreissena bugensis*), which are closely related to zebra mussels and may have similar affects on the water clarity. A notable increase in water clarity has occurred in the Lake within the past five years, which overlaps the time period in which quagga mussels were discovered in Geneva Lake. While a causal link between quagga mussels and increased clarity cannot be established at this time, continued monitoring of water clarity will be an important part of any future water quality assessments and for evaluating the impact of quagga mussels on the Lake's ecology.

Phosphorus

The second major determinant of a lake's trophic status is the concentration of total phosphorus in the lake's water. Phosphorus is a key nutrient for aquatic plants and algae, with the availability of phosphorus often limiting their growth and abundance. Sources of phosphorus can vary across a watershed, with agricultural fertilizers and animal manure as the predominant phosphorus sources in rural areas while stormwater discharge and onsite wastewater treatment systems contribute phosphorus in urban areas.

Two forms of phosphorus are commonly sampled in surface waters: total phosphorus and dissolved phosphorus. Total phosphorus consists of all the phosphorus contained in material dissolved or suspended in water. Dissolved phosphorus consists of the phosphorus contained in material dissolved in water. In both these types, phosphorus may be present in a variety of chemical forms. However, as the degree of eutrophication in freshwater systems correlates more strongly with total phosphorus concentration than with dissolved phosphorus concentration, the State's water quality criteria are expressed in terms of total phosphorus. Thus, water quality sampling tends to focus on assessing total phosphorus concentrations rather than dissolved phosphorus concentrations.

Through continued monitoring efforts by the GLEA, WDNR, and USGS, Geneva Lake has been heavily sampled for total phosphorus with 2,043 samples collected between 1960 and 2025. Over 79 percent of these samples have been collected in the western end of the Lake at the USGS "west end" site and the nearby WDNR "deep hole" site. Several monitoring sites around the lake, including the Narrows and Geneva Bay, were last monitored for total phosphorus in the 1990s while Williams Bay was last monitored in 2010. The GLEA restarted monitoring for total phosphorus in the eastern portion of the Lake in spring 2025, which hadn't been previously sampled since 2014. The Lake has averaged a median of 53 samples per year, with the most samples in 1998 (242 samples) and the fewest in 1960 (one sample). Across all monitoring sites and sampling dates, the total phosphorus concentrations ranged from non-detectable to 0.21 mg/l, with a median concentration of 0.012 mg/l and a mean concentration of 0.018 mg/l.

Total phosphorus concentrations are typically higher below the thermocline than above it due to differences in water chemistry in the oxygenated epilimnion compared to the anoxic hypolimnion. Approximately 68 percent of the total phosphorus samples were collected in water deeper than 30 feet;[125] across all sites, these samples had significantly higher concentrations (median of 0.012 mg/l and mean of 0.022 mg/l) than the samples collected shallower than 30 feet (median of 0.011 mg/l and mean of 0.012 mg/l) ($p < 2x10^{-16}$; see Figure 2.17). Total phosphorus concentrations were particularly high in the deepest areas of the Lake; of the 134 samples with a total phosphorus concentration exceeding 0.05 mg/l, 130 of these samples were collected in the hypolimnion at water depths of 100 feet or greater. Hypolimnion phosphorus concentrations that are much higher than epilimnion concentrations are an indicator of significant internal loading, which is discussed in Section 2.5, "Pollutant Loading."

For samples collected in the epilimnion, total phosphorus concentrations are significantly different across the Lake ($p < 0.0004$), with higher concentrations in the "West End" site than the "East End" and "Lake Center." There were no significant trends in total phosphorus concentrations over time for epilimnion samples across all sites or at any particular site on the Lake. However, there was a weak but significant increase in total phosphorus over time for deep (greater than 30 feet) samples ($p = 0.016$, $R^2=0.003$). This effect is particularly notable at the deepest depths of the lake (greater than 100 feet), where total phosphorus concentrations exceeded 0.15 mg/l for the first time in summer 2024 (see Figure 2.18).

Orthophosphate is a dissolved form of phosphorus that is more readily utilized by algae and aquatic plants in waterbodies. Although the WDNR has not published water quality standards for orthophosphate, its concentrations within a lake can provide another indicator of a lake's trophic state. GLEA and other agencies have collected nearly 1,200 observations of orthophosphate in Geneva Lake since 1988. As with total phosphorus, the majority (73 percent) of orthophosphate samples on Geneva Lake have been collected at the "West End" monitoring site, including every sample collected since 2000. Across all samples, orthophosphate concentrations ranged from 0.001 to 0.331 mg/l, with median and mean concentrations of 0.006 and 0.020 mg/l, respectively. Like total phosphorus, orthophosphate concentrations in the hypolimnion (mean of 0.0313 mg/l) are significantly greater than concentrations in the epilimnion or thermocline (means of 0.0056 and 0.0057, respectively), which did not significantly differ from each other ($p < 2x10^{-16}$). Concentrations of orthophosphate have significantly increased in each layer of the Lake over

[125] *Thirty feet was determined as the average depth where the thermocline begins in Geneva Lake in summer based on the temperature and dissolved oxygen profiles.*

time, with the greatest rate of increase in the hypolimnion (see Figure 2.19). These increases, particularly in conjunction with the increase in hypolimnetic total phosphorus concentrations and other trophic indicators, suggest that Geneva Lake is becoming increasingly nutrient-rich.

Chlorophyll-a

Chlorophyll-a, a photosynthetic pigment whose abundance is used to indicate algal biomass, is the most reliable metric of a lake's trophic status. Algae is an important and healthy part of lake ecosystems. Algae is a foundational component of lake food chains and produces oxygen in the same way as rooted plants. Many kinds of algae exist, from single-cell, colonial, and filamentous algae to cyanobacteria. Most algae strains are beneficial to lakes when present in moderate levels. However, the presence of toxic strains, as well as excessive growth patterns, should be considered issues of concern. As with aquatic plants, algae grows faster in the presence of abundant phosphorus (particularly in stagnant areas). Consequently, when toxic or high volumes of algae begin to grow in a lake, it often is a sign of phosphorus enrichment or pollution.

Algae populations are quantified by abundance and composition and can be examined to determine if the algae present are toxin-forming. Suspended algal abundance is estimated by measuring the chlorophyll-a concentration in the water column, with high concentrations associated with green-colored water. Since 2010, chlorophyll-a concentrations in the Lake have a mean concentration of 2.84 µg/l and a median concentration of 2.39 µg/l. Although concentrations have slightly decreased since the first observations in 1988, chlorophyll-a concentrations have slightly increased since 2010 due in part to two particularly high concentrations observed on July 22, 2020 and April 28, 2022 at 14.9 and 11.7 µg/l, respectively (see Figure 2.20). These concentrations, which are the highest measurements of chlorophyll-a in the Lake's record, exceed the WDNR chlorophyll-a criteria for two-story lakes of 8 µg/l and thus may represent further evidence of increasing nutrient enrichment in the Lake.[126]

Trophic State Index

Lake biological productivity is referred to in terms of "trophic state." Low productivity lakes with few nutrients, algae, and plants are in an oligotrophic state; lakes with moderate nutrients and productivity are in a mesotrophic state; and lakes with excessive nutrients and productivity are in a eutrophic state.

[126] *WDNR WisCALM, 2024*, op. cit.

Wisconsin trophic state index (WTSI) equations are used to convert measurements of summer water clarity, measured using a Secchi disk; chlorophyll-a, a measure of algae abundance; and total phosphorus concentrations to a common unit used to assess the overall productivity and thus trophic state throughout Wisconsin.[127] WTSI values based upon chlorophyll-a are considered the most reliable estimators of lake trophic state as this is the most direct measurement of algal abundance. This common unit allows lake-specific information to be compared to other lakes.[128] WTSI values are used to determine the trophic state of a lake, either oligotrophic, mesotrophic, or oligotrophic.

Commission staff used the water clarity, total phosphorus, and chlorophyll-a data to calculate the trophic state index for each parameter for Geneva Lake. As illustrated in Figure 2.21, the chlorophyll-a and secchi depth data indicate that the lake should be considered bordering on oligotrophic to mesotrophic conditions. However, the total phosphorus concentrations shows the opposite pattern with mesotrophic conditions trending toward eutrophic conditions. Historically, these parameters would frequently trend together as total phosphorus is the essential nutrient that stimulates algal growth and higher algal growth reduces water clarity. The disconnect between total phosphorus with clarity and chlorophyll-a is more recently observed in many southeastern Wisconsin lakes that have infestations of zebra mussels, which act to filter the algae and improve water clarity even though the lake has enhanced phosphorus concentrations. The introduction of quagga mussels to Geneva Lake may further exacerbate this disconnect, as quagga mussels can colonize soft sediments (thus increasing in total mussel abundance compared to zebra mussels) and are more prolific filter feeders than zebra mussels. The improved water clarity may provide a false impression of better water quality conditions, but the increasing total phosphorus concentrations can stimulate more frequent algal blooms and indicate that nonpoint source phosphorus loading is a concern for the lake.

Nitrogen

Surface waters contain a variety of nitrogen compounds that are nutrients for plants and algae. Typically, only a small number of forms of nitrogen are examined and reported in water quality sampling. Total

[127] *R.A. Lillie, S. Graham, and P. Rasmussen, Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes, Research Management Findings, Number 35, Bureau of Research – Wisconsin Department of Natural Resources, May 1993.*

[128] *Ibid.*

nitrogen includes all of the nitrogen in dissolved or particulate form in the water, excluding all gaseous forms of nitrogen. Total nitrogen is a composite of several different compounds that vary in their availability to algae and aquatic plants and in their toxicity to aquatic organisms. Many nitrogen-containing organic compounds, such as amino acids, nucleic acids, and proteins that commonly occur in natural and polluted waters are included in total nitrogen. Common inorganic constituents of total nitrogen include ammonia, nitrate, and nitrite. These are the forms that most commonly support algal and plant growth. Nitrate (NO3) can be toxic to humans at high concentrations (WDNR drinking water limit is 10 mg/l of nitrate as nitrogen).

A variety of point and nonpoint sources contribute nitrogen compounds to surface waters. In urban settings, nitrogen compounds from lawn fertilizers and other sources may be discharged through storm sewer systems and direct runoff into streams. Cross-connections between sanitary and storm sewer systems, illicit connections to storm sewer systems, and decaying sanitary and storm sewer infrastructure may contribute sanitary wastewater to waterbodies through discharges from storm sewer systems. In rural settings, nitrogen compounds from chemical fertilizers and animal manure may be contributed through discharges from drain tiles or direct runoff into waterbodies. Poorly maintained or failing onsite wastewater treatment systems can also contribute to nitrogen compounds. In addition, some species of lake cyanobacteria "fix" nitrogen by converting otherwise inert gaseous nitrogen into ammonia or another compound usable by algae and plants.

Occasionally, nitrogen acts as the limiting nutrient for algal and plant growth in freshwater systems, typically when phosphorus concentrations are very high. In general, when the ratio of total nitrogen (N) to total phosphorus (P) concentrations is 15:1 or greater, the availability of phosphorus limits algal growth. Conversely, when this proportion is less than 10:1, nitrogen concentrations limit plant growth. Ratios between 15:1 and 10:1 are considered transitional.[129] During spring turnover on the Lake between 1997 and 2020, N:P ratios typically averaged 44:1, and ranged from as low as 18:1 to as high as 110:1; such ratios clearly indicate that phosphorus is the main limiting factor for plant and algae growth. Spring nitrogen concentrations in the Lake have fluctuated between 0.3 and 1.3 mg/l from 1997 to 2021, with the most recent spring measurement at 0.53 in April 2021 (see Figure 2.22). Median summer and fall total nitrogen concentrations between 1997 and 2022 were 0.6 and 0.59 mg/l, respectively. Concentrations have slightly increased over time in both seasons, but this may be due in part to a higher proportion of deep water sampling in recent years. As with total phosphorus, total nitrogen concentrations are typically higher in

[129]*Lillie and Mason, 1983,* op. cit.

deeper water (over 20 feet deep) than in shallow water. These concentrations and N:P ratios indicate that phosphorus should be the major focus of nutrient loading and algae bloom management decisions.

Bacteria

The concentration of certain bacteria in water is measured in order to assess the quality of the water for drinking water supply and recreational uses. A variety of disease-causing organisms can be transmitted through water contaminated with fecal material. These organisms include bacteria, such as those causing cholera and typhoid fever; viruses, such as those causing poliomyelitis and infectious hepatitis; and protozoa, such as *Giardia* and *Cryptosporidium*. It is not practical to test surface waters for all of these disease-causing organisms as rapid and inexpensive tests do not currently exist for many of these organisms. Instead, the sanitary quality of surface water is assessed by examining samples for the presence and concentrations of organisms indicating fecal contamination. Two groups of bacteria are commonly examined in surface waters of southeastern Wisconsin: fecal coliform bacteria and *Escherichia coli* (*E. coli*). All warm-blooded animals have these bacteria in their feces, so the presence of high concentrations of fecal coliform bacteria or *E. coli* in water indicates a high probability of fecal contamination. While most strains of these two bacterial groups have a low probability of causing illness they do act as indicators of the possible presence of other pathogenic agents in water, particularly when present in high concentrations.

Fecal coliform bacteria were previously currently used to indicate the suitability of inland waters in Wisconsin for recreational uses, but the WDNR has now adopted use of *E. coli* to determine recreational suitability.[130] Previously, the WDNR required that counts of fecal coliform bacteria in waters of the State not exceed 200 colony-forming-units (a measure of living cells) per 100 milliliters (cfu per 100 ml) as a geometric mean based on not less than five samples per month, nor exceed 400 cfu per 100 ml in more than 10 percent of all samples during any month. Based on observations stored in the WDNR water quality database, Geneva Lake was sampled for fecal coliform 27 times between 1999 and 2009 at beaches near the City of Lake Geneva, Village of Fontana, Village of Williams Bay, and Bigfoot Beach State Park. Only one exceedance of the 200 cfu per 100 ml standard was recorded, which was at the City of Lake Geneva beach in 2006.

E. coli is a species of fecal coliform bacteria. The USEPA recommends using either *E. coli* or enterococci as indicators of fecal pollution in recreational waters for freshwater systems. Agencies participating in the

[130] *WisCALM, 2024,* op. cit.

monitoring of beaches in the Wisconsin Beach Monitoring program use *E. coli* as the indicator of sanitary quality of the associated waters. Water quality advisories are issued for beaches whenever the concentration of *E. coli* in a sample exceeds 235 cfu per 100 ml or whenever the geometric mean of at least five samples taken over a 30-day period exceeds 126 cfu per 100 ml. Beaches are closed whenever the concentration of *E. coli* exceeds 1,000 cfu per 100 ml.

The GLEA monitors levels of *E. coli* weekly during summer (late May through August) at several beaches around Geneva Lake: City of Lake Geneva, Village of Fontana, Village of Williams Bay, Linn Pier and Hillside Road boat launch in the Town of Linn, and Bigfoot Beach State Park.[131] Between 2002 and 2025, approximately 4,900 *E. coli* samples have been collected with concentrations ranging between non-detectable to over 2,420 cfu per 100 ml and a mean concentration of 63.9 cfu per 100 ml. Across all samples, less than 4 percent have been within beach advisory concentrations (235 to 999 cfu per 100 ml) and just over one percent have exceeded closure concentrations (1,000 cfu per 100 ml). Per 2025 GLEA protocol, Commission staff calculated mean *E. coli* concentrations per sampling date and monitoring location to evaluate *E. coli* conditions and trends over time in the Lake (see Figure 2.23). The Hillside and Lake Geneva monitoring locations have the greatest number of closure concentrations, but conditions appear to have recently improved at the Hillside location as the site has not exceeded advisory or closure concentrations since 2022. Fontana and Linn Pier have never attained closure concentrations and have the fewest number of advisory concentrations.

Tributary Streams

As described in Section 2.2, "Lake and Watershed Characteristics," Geneva Lake receives water from more than 50 tributary streams across its watershed (see Map 2.7). Many of these tributaries only flow intermittently and are unmapped by regional or state agencies and consequently have little water quality information collected. However, several of these tributaries, particularly Bigfoot Creek, have been the focus of interest and study by lake stakeholders due to their importance on pollutant loading to Geneva Lake. This section will summarize recent water quality monitoring efforts conducted on Geneva Lake tributaries.

[131] *For more information regarding the GLEA's* E. coli *monitoring, see the following link: https://www.gleawi.org/about-4-1.*

Bigfoot Creek

Bigfoot Creek is one of many tributaries that feed into Geneva Lake. The creek's inlet is located on the eastern shoreline of the Lake and empties into Buttons Bay just south of Big Foot Beach State Park (see Map 2.21). The creek has been observed to discharge red-colored water into the Lake, particularly after heavy rains (see Figure 2.24).[132] However, concerns around this water are not just aesthetic as the proximity to Bigfoot Beach has been a driving factor for the monitoring and investigation into the cause of the red water and what pollutants the Creek contributes to Geneva Lake.

Beyond its red-colored water as a point of concern, Bigfoot Creek has been the subject of water quality studies for several decades due to its unusually high concentrations of phosphorus, ammonia, and other concerning water quality parameters. The Bigfoot Creek watershed is less developed than many of Geneva Lake's other tributary stream watersheds. While a small portion of the northern area of the watershed drains residential and commercial areas of the City of Lake Geneva, the Creek's watershed primarily consists of agricultural, open, wetland, or woodland areas, suggesting that a significant portion of the watershed is not covered by impervious surfaces. Although the Bigfoot Creek watershed is less developed, it has been severely influenced by historical land use, including the operation of the Otto Jacobs Landfill sites in the mid-20th century and the draining of wetlands in the area. It has been suspected that a history of landfills, drain tiling and wetland degradation in the watershed may be responsible for some of the creek's water quality decline. Furthermore, an additional historic feature along Bigfoot Creek that may be useful for understanding water flow and quality within the watershed is a former racetrack. This oval track is visible in aerial photographs and can be seen crossing the eastern branch of Bigfoot Creek between State Trunk Highway (STH) 120 and the shoreline of Geneva Lake.

Historical Water Quality Conditions

Bigfoot Creek, formerly known as Button's Bay Creek, was one of the perennial streams with water quality parameters evaluated in the Geneva Lake's 1985 Water Quality Management Plan detailed in SEWRPC Community Planning Report No. 60.[133] The plan identified the Creek as one of the perennial streams with the poorest water quality and noted that it was an atypical stream that flowed intermittently. Data from this

[132] *A Preliminary Investigation of Big Foot Creek's Degraded Water Quality. Geneva Lake Environmental Agency. August 1993.*

[133] *SEWRPC Community Assistance Planning Report No. 60,* A Lake Management Plan for Geneva Lake, Walworth County, Wisconsin, *October 1985.*

report also indicated that the Creek had higher total phosphorus, ammonia, and total Kjeldahl nitrogen than in the other streams, averaging 1.43 mg/l, 1.22 mg/l and 5.57 mg/l, respectively. Additionally, dissolved solids and chloride levels were high compared to other tributaries to Geneva Lake. At that time, the cause of higher pollutant concentration was not determined, but it was suspected that elevated pollutant levels may have resulted from the flushing of materials into the stream during low or non-flow periods. The report also cited domestic animal waste from adjacent pastureland as well as the local sanitary landfill as possible sources of pollutants.

Various additional studies have since confirmed degraded water quality in Bigfoot Creek and continued to raise concerns about the Creek's impact on Geneva Lake's water quality. In 1993, staff from the Geneva Lake Environmental Agency investigated the creek, taking groundwater and surface water samples to be tested for dissolved oxygen, chemical oxygen demand (COD), pH, alkalinity, phosphorus, suspended solids, total volatile solids, conductivity, temperature, and total iron. The 1993 GLEA investigation concluded that the wetland that surrounds much of the creek is contributing to water quality degradation. However, the report also stated that the duration, frequency and high concentration of eutrophic indicators led them to believe that the red water and pollutant loading was not entirely a natural phenomenon. [134,135]

Following the 1993 report, the GLEA conducted a study to determine if the Otto Jacobs Landfill site was also contributing contaminants to Bigfoot Creek. [136] The Otto Jacobs Landfill sites have been investigated several times to ensure compliance with the closing of the landfill in 1980 and to ascertain if any

[134] *A Preliminary Investigation of Big Foot Creek's Degraded Water Quality. Geneva Lake Environmental Agency. August 1993.*

[135] *Preliminary Comments on the September 15, 1993 Sampling Within the Buttons Bay Creek Watershed. Geneva Lake Environmental Agency. March 16. 1994.*

[136] *Gustafson, Karl.* Analysis of the Chemical Contamination from the Otto Jacobs Landfill Site in Lake Geneva, WI. *Geneva Lake Environmental Agency. May 17, 1994.*

contaminants were leaking from the landfill. [137,138,139,140] The Otto Jacobs Landfill site is located about 0.5 miles south of Geneva Lake and is comprised of three landfills that total around 14 acres (see Map 2.21). The exact year of the landfill's opening is unknown, but it is believed to have opened prior to 1969, potentially as early as the late 1950s. [141] During the time of the landfill's operation, an unknown amount of waste was accepted and deposited into the landfill believed to contain possible contaminants such as solvents, lacquers, nitrocellulose base layers, scrap oils, corrosive strippers, and naphtha. Through the duration of the landfill's operation, the Wisconsin DNR reported several instances of violations including burning, underground fires, waste left uncovered for prolonged periods of time, and leachate and sludge discharge into the wetlands that border the sites.[142] After its closure, the three landfill sites have been covered and graded. The area was then used primarily as grazing land for the Jacobs family livestock.[143] The sites were later subject to a closed landfill compliance inspection in June 2023 by the WDNR and, while no noncompliance items were found, the owner of that property took corrective action to remedy any concerns identified in the inspection to the WDNR's satisfaction.[144] Currently the property where the landfills are located is used for hunting.

[137] *Hydrogeologic Report on the Otto Jacobs Landfills site, Lake Geneva, WI. WID980610703, TDD: F05-8611-182. Ecology and Environment, Inc. December 18, 1986.*

[138] *WDNR Compliance Monitoring and Evaluation Form, FID# 265063590, Case #: 74434*

[139] *K. Gustafson, 1994,* op. cit.

[140] *The Otto Jacobs property has been the subject of several Environmental Site Assessments over the years including a Phase 1 and 2 ESA from 2005 and a Phase 1 and 2 ESA from 2019. Only Phase 1 from 2019 prepared by TRC Environmental Corporation was available to Commission Staff during the writing of this report. The 2019 ESA Phase 2 also noted that copies of the 2005 ESA phase reports were unavailable.*

[141] *Hydrogeologic Report on the Otto Jacobs Landfills site, Lake Geneva, WI. WID980610703, TDD: F05-8611-182. Ecology and Environment, Inc. December 18, 1986.*

[142] *Ibid.*

[143] *Ibid.*

[144] *Letter from David Buser, Waste Management Hydrogeologist at the WDNR to Duke Potter, July 24th, 2023. File Reference: FID 265063590.*

In 1998 and 1999, the GLEA collaborated with the USGS to construct a hydrologic and phosphorus budget for Geneva Lake.[145] This effort included total phosphorus measurements on Bigfoot Creek during baseflow and high flow conditions in both years with particularly high concentrations observed during baseflow. These concentrations demonstrated a seasonal pattern, with low concentrations from October to April and increasing concentrations up to 1.5 mg/l in mid-summer before decreasing in late summer. The study authors noted that the extensive wetland in this watershed may contribute to this pattern, which they also observed at the inlet to nearby Delavan Lake. Bigfoot Creek had the highest estimate phosphorus load of any lake tributary in the drier 1998 water year but had a substantially lower load than Birches Creek in the wetter 1999 water year.

In 2020 and 2021, the GLEA conducted a two-phase Watershed Study on Bigfoot Creek. In the first phase of the study, the GLEA further investigated Bigfoot Creek's water quality and underlying causes for the Creek's distinct red color.[146] A leading theory explored in the study was that, as groundwater—believed to be a significant source of water to Bigfoot Creek—becomes exposed to the atmosphere, with the help of oxygen, dissolved iron in the groundwater becomes insoluble, forming red flocculant or iron. This process uses oxygen in the water, reducing dissolved oxygen levels and resulting in reduction of nitrogen. Low oxygen then also results in inorganic phosphorus that is bound to sediment being released to the surface waters as well as red flocculant of insoluble iron, high organic phosphorus, high ammonia nitrogen and low dissolved oxygen. The 2020 study found that groundwater samples taken from within the Bigfoot Creek watershed were more similar to Geneva Lake than to Bigfoot Creek water samples. The Creek showed degradation in almost all major water quality parameters, including phosphorus and ammonia, and chemical oxygen demand (COD) in the creek indicated that dissolved oxygen (DO) was being used at a higher rate than it was being replaced. Overall, the 2020 report concluded that Bigfoot Creek is a significant source of pollutants to Geneva Lake. As Geneva Lake is a phosphorus limited lake that meets its recommended phosphorus standard, if phosphorus loading continues at its current rate from Bigfoot Creek, it will eventually exceed the Lake's phosphorus standard and lead to considerable water quality decline.[147]

[145] *United States Geological Survey,* Hydrology and Water Quality of Geneva Lake, Walworth County, Wisconsin*, USGS Water-Resources Investigations Report 02-4039, 2002*.

[146] *Geneva Lake Environmental Agency,* Big Foot Creek Watershed Study Phase 1, Geneva Lake, Walworth County, WI 2020*, 2020*.

[147] *Ibid.*

In the second phase of the Bigfoot Creek Watershed Study, Resource Environmental Solutions (RES) further showed that Creek water samples exceeded regulatory criteria for iron and phosphorus.[148] More specifically, results from the 2021 RES study showed average iron concentrations ranging from 10.9 mg/l to 12.1 mg/l and phosphorus concentrations between 0.65 mg/l and 0.69 mg/l within the Creek. This 2021 RES study indicated that the likely source of high phosphorus and iron levels in Bigfoot Creek and the Creek's distinct red color were the result of a chemical reaction caused by drained wetlands and muck soils. RES recommended the construction of limestone treatment wetlands to reduce excessive Phosphorus and iron levels entering Bigfoot Creek and subsequently Geneva Lake. However, as the creation of such wetlands would be extremely time-intensive and costly, additional research aimed at identifying the source of the pollutants was subsequently conducted.

An examination of water quality in tributaries of the Geneva Lake watershed was completed from late spring to early fall in 2021 and 2022 by University of Wisconsin Whitewater Professor Dr. Dale Splinter. [149] In 2022, Bigfoot Creek had high concentrations of total phosphorus exceeding 0.075 mg/l, Wisconsin's current total phosphorus criteria. Furthermore, Bigfoot Creek had the highest concentrations of total phosphorus in every month of the sampling year (May through October) when compared to other Geneva Lake tributaries sampled. Samples exceeded Wisconsin's criteria for phosphorus each month of the 2022 study period with the highest concentration (0.415 mg/l) reported by the Wisconsin State Laboratory of Hygiene in August. Bigfoot Creek was officially included as a phosphorus impaired waterbody in 2022 (under the name Buttons Creek) on the Wisconsin Clean Water Act 303(d) Impaired Waters list.

Similarly, Total Kjeldahl Nitrogen (TKN) values were also high in Bigfoot Creek. These values may be related to the organic matter in the wetland through which the stream originates. TKN concentrations ranged from 1.44 mg/l in June to 2.62 mg/l in July 2022, with an average concentration of 1.89 mg/l during the study period. TKN was similarly significantly higher in Bigfoot Creek than in other tributaries entering Geneva Lake. The greatest concentration of ammonia in the study was also recorded in Bigfoot Creek and DO levels were the lowest in the Creek compared to all locations sampled in the watershed. Each of these parameters further indicated poor water quality and high pollution levels in the Creek. As a result, Dr. Splinter's 2023

[148] *Resource Environmental Solutions, LLC,* Big Foot Creek Water Quality Study, Phase 2 Final Report*, 2021*.

[149] Splinter, Dale. A Late Spring-to-Early Fall Examination of Water Quality in Tributaries of the Geneva Lake Watershed: 2021-2022. University of Wisconsin Whitewater. Submitted to GLC on October 6th 2023.

report called for more detailed studies focused on nutrient loading and a better understanding of the specific routing of nutrients into Bigfoot Creek.[150]

July 2024 Water Quality Assessment

To further examine the path of nutrients and potential contaminants entering Bigfoot Creek, SEWRPC staff carried out a longitudinal water quality survey in July of 2024. Both the sampling locations and the suite of water quality parameters measured were selected to more closely evaluate possible leachate contamination from the Otto Jacobs landfills as well as contaminants originating from the surrounding wetland complex. Historically categorized as wet prairie, the wetlands through which Bigfoot Creek flows today are largely dominated by extensive monocultures of hybrid cattail (*Typha x glauca*). Following disturbance or drainage, hybrid cattail can rapidly invade a degraded wetland and further impact the aquatic system's ecology and function.

In July 2024, Commission staff collected samples at six points within Bigfoot Creek (see Map 2.22). The sampling locations included an upstream site (BC1) northeast of the closed Otto Jacobs Landfills, a site on the northeastern corner of the remnant horse track or "horseshoe" (BC2), two sites on the southern edge of the horseshoe near the previous landfill locations (BC3 and BC4), and two sites north of the landfill locations on the Creek's mainstem (BC5 and BC6). A seventh site was also sampled on a nearby stream, Southwick Creek, to serve as a reference site. While Southwick and Bigfoot Creek were sampled on the same day, the streams differ in surrounding land use composition and may not serve as a perfect comparison. Water samples were analyzed by the Wisconsin State Lab of Hygiene.

At the time of sampling, site BC1, east of the horseshoe, had brown, turbid, and stagnant water. Sediment consisted of flocculent muck, which was consistent throughout the Creek. Downstream at BC2, on the northeast corner of the horseshoe, the water was brown in color but less turbid. There were several submerged aquatic plants and both duckweed (*Lemna sp*. and *Spirodela sp*.) and watermeal (*Wolffia sp*.) were present in large quantities. At the two sites on the southern end of the horseshoe (BC3 and BC4), the water was clearer and less turbid. Site BC3 near one of the Otto Jacobs landfills had higher DO concentrations (5.7 mg/l) than previously recorded at BC1 and BC2, and there were a number of aquatic plants present, including white water crowfoot (*Ranunculus aquatilis*) which could indicate the presence of

[150] *Ibid.*

cold groundwater flow to the Creek near this site. To the west of this site at BC4, the water became more turbid and was once again dominated by duckweed and watermeal. The sediment remained flocculent and the water was brown. BC5, north of the horseshoe, was noticeably more orange in color than any of the eastern or downstream sampling locations and had submerged iron flocculant. Similarly, site BC6 downstream was brown to orange in color, turbid and fed by a nearby tributary—also orange in color—flowing to the site from the wetlands to the north (see Table 2.9).

Total Phosphorus

Results from the July 2024 sampling effort indicated that total phosphorus concentrations were high throughout Bigfoot Creek, with the highest total phosphorus levels (4.8 mg/l) observed northwest of the horseshoe at BC6 (see Figure 2.25). Notably, this site was outside of the horseshoe and downstream from the historical landfill locations. Conversely, total phosphorus was lowest at sites BC3 and BC4 at which concentrations were 0.076 mg/l and 0.297 mg/l, respectively. Sites BC3 and BC4 were the two sampling locations nearest to the Otto Jacobs Landfills on the southern end of the horseshoe. While considerably lower at the southernmost sampling locations, all total phosphorus concentrations recorded surpassed Wisconsin's total phosphorus criteria indicating poor water quality that poses a significant risk to aquatic life. When compared to the nearby reference site of Southwick Creek, TP concentrations were significantly higher among Bigfoot Creek samples. Total Phosphorus in the sample taken from Southwick Creek was 0.0275 mg/l.

Nitrogen

Figure 2.25 contains individual graphs for Total Kjeldahl Nitrogen (TKN), ammonia, and nitrate and nitrite (as nitrogen) concentrations throughout Bigfoot Creek in July 2024. TKN ranged from 1.4 mg/l at BC3 to an extremely high 13.9 mg/l at BC6. A measure of organic nitrogen and ammonia within as stream, high TKN in Bigfoot Creek indicate eutrophic conditions, which are further supported by the low dissolved oxygen observed in the Creek (0.5 mg/l at BC6) (Table 2.9). Ammonia levels followed a similar trend, with the lowest value recorded at BC3 and highest at BC6. Though higher than reported previously in Bigfoot Creek, nitrate and nitrite levels across sampling sites were less elevated, with most samples reported below 2.4 mg/l, with the exception of BC6 which had a nitrogen concentration of 3.96 mg/l.

Oxygen Conditions

Bigfoot Creek had consistently low Dissolved Oxygen (DO) at all sites aside from BC2, ranging from 0.1 mg/l to 9 mg/l, and had high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) (see Table 2.9 and Figure 2.25). The highest BOD concentration recorded was an extremely elevated 62.3 mg/l at BC6 while BOD was lowest near the two sites on the southern end of the horseshoe (BC3 and BC4) near the landfills. Chemical oxygen demand (COD) in Bigfoot Creek was also high across the six sampling locations but was highest at BC6 (388 mg/l) and lowest at BC3 (29.2 mg/l). In the study's reference stream, Southwick Creek, dissolved oxygen was also fairly low (3.4 mg/l). However, BOD, COD and TKN differed significantly in Southwick from Bigfoot Creek. Most notably, BOD and COD in Southwick Creek were 16.4 mg/l and 9.39 mg/l, respectively and TKN was less than 0.5 mg/l. Elevated levels of ammonia and TKN yet relatively low nitrate and nitrite in Bigfoot Creek seem to suggest that BOD and COD may be creating extremely anoxic in-stream conditions when compared to other nearby streams in the watershed.

Iron

As previously mentioned, red flocculant was recorded throughout the Creek with the most flocculant-rich sites located downstream of the northwestern side of the horseshoe (BC5 and BC6). During sample collection, all sites were classified as having brown to orange water (see Table 2.9). Iron was suspected to be the cause of the red/orange color and site samples ranged in iron concentration from 0.213 mg/l to 106 mg/l (see Figure 2.25). Many of the iron concentrations recorded were significantly higher than iron levels seen historically and surpassed the Environmental Protection Agency (EPA) suggested chronic value of 1.0 mg/l in streams for freshwater aquatic life. Observed levels of iron in Bigfoot Creek differed significantly from Southwick creek as a reference stream. Southwick creek had an iron concentration of 0.35 mg/l, which more closely resembled samples taken from sites BC3 and BC4 near the landfills.

Chloride

Chloride concentrations were highest at BC1 (99.9 mg/l) and BC2 (105 mg/l), the two sampling locations upstream of the wetland and the horseshoe (see Figure 2.25). Non-point runoff from adjacent agricultural areas and roads may have been responsible for these higher chloride levels upstream while chloride concentrations were lower (27.8 mg/l and 21.7 mg/l) at sites BC3 and BC4 near the Otto Jacobs landfill sites. While slightly elevated, the concentrations observed in Bigfoot Creek were well below Wisconsin's chronic and acute toxicity thresholds for chloride. Four sites (BC1, BC2, BC5 and BC6) had chloride concentrations that surpassed the conservative lower impact concentrations (35 mg/l), the lowest concentration known to negatively affect aquatic life.[151]

August 2024 Water Quality Assessment

In August 2024, a second sampling effort was carried out by the Geneva Lake Conservatory (GLC). Similar to the July water quality analysis conducted by Commission staff, the GLC collected samples from various locations along Bigfoot Creek to assess water quality. While the majority of these locations differed from the SEWRPC sites, there were two overlapping sites shared by the 2024 sampling efforts. The GLC survey also included sites farther downstream near Geneva Lake and upstream at a pond northeast of the Creek (see Map 2.22), extending the area in which water quality was evaluated during the 2024 season.

<u>Total Phosphorus</u>

Total phosphorus was significantly higher in Bigfoot Creek in August when compared to the previous month of sampling. The highest recorded total phosphorus level was observed at the mouth of the creek near Geneva Lake and Big Foot Beach State Park. On the day of sampling, there was a substantial algae bloom reported near the shore of Geneva Lake. This high total phosphorus measurement of 47.0 mg/l likely reflected the algae bloom and was influenced by the lake itself at GLC site BF5. However, total phosphorus was high within the creek upstream from the outlet as well. At the two sites that were consistent with the Commission's July sampling locations (BC1 and BC4), the GLC reported total phosphorus concentrations of 2.83 mg/l and 1.21 mg/l, respectively (see Figure 2.26). These levels were similar to those observed by SEWRPC the previous month.

<u>Nitrogen</u>

August 2024 total Kjeldahl nitrogen concentrations were higher than those observed the previous month. At site BF1 (SEWRPC site BC1), TKN increased from 3.3 mg/l in July to 17.4 mg/l in August. At GLC site BF4 (SEWRPC site BC2), TKN also increased from 2.69 mg/l to a concerning 33.4 mg/l. Similarly to total phosphorus, TKN concentrations were highest where Bigfoot Creek entered Geneva Lake (49 mg/l) (see Figure 2.26). Ammonia levels recorded within the Creek in August 2024 ranged from 0.0572 mg/l at the pond upstream to 0.91 mg/l at GLC sampling location BF1 (SEWRPC site BC1) and nitrate and nitrite levels increased from July samples (see Figure 2.26). Most notably, nitrate and nitrogen at BF4 (SEWRPC BC2) rose

[151] *SEWRPC Technical Report No. 62,* Impacts of Chloride on the Natural and Built Environment*, April 2024.*

from a fairly low 1.86 mg/l to 24.5 mg/l. These increases in TKN, ammonia, nitrate and nitrite in August 2024 may be related to higher temperatures, less in-stream flow, algal blooms or other seasonal factors.

Oxygen Demand

The most concerning observations from the August 2024 sampling effort were the elevated biochemical and chemical oxygen demands within Bigfoot Creek. The highest BOD level recorded by the GLC was 69.9 mg/l at BF1 (SEWRPC site BC1), a significant increase from the 28.9 mg/l recorded in July (see Figure 2.26). COD also increased from July to August with an extremely high COD level of 1,490 mg/l observed near the mouth of the creek at Geneva Lake and the second highest level (744 mg/l) recorded upstream at GLC site BF4 (SEWRPC site BC2) (see Figure 2.26). The extremely elevated BOD and COD observed in Bigfoot Creek in both July and August were consistent with highly degraded and polluted streams.

Iron

Iron concentrations within the Creek also increased in August when compared to July 2024 samples. The highest iron concentration (281 mg/l) was recorded at the farthest downstream sampling location near Big Foot Beach State Park on Geneva Lake (BF5). Upstream concentrations were also elevated, ranging from 11.1 mg/l to 56.6mg/l (see Figure 2.26). The significant concentrations of iron measured in August 2024 samples were likely responsible for the red, flocculent water at the time of sampling. These concentrations surpassed the Environmental Protection Agency (EPA) suggested chronic value of 1.0 mg/l in streams for freshwater aquatic life.

Chloride

Chloride differed from other water quality constituents, decreasing in concentration in August from July 2024. During the August GLC sampling period, chloride concentration in Bigfoot Creek ranged from 26.9 mg/l to 60.9 mg/l (see Figure 2.26). The highest concentration of chloride was recorded at BF1 (SEWRPC site BC1) and is likely influenced by contributions from neighboring agricultural land and roads. The lowest chloride concentration was observed at the mouth of Bigfoot Creek and may be diluted by Geneva Lake. August chloride levels, similar to those recorded by SEWRPC the previous month, remained below Wisconsin's chronic toxicity threshold. Three sites had chloride concentrations that surpassed the conservative lower impact concentration (35 mg/l), which may negatively affect aquatic life in the Creek.[152]

[152] *Ibid.*

Water Quality Conclusions

Decades of water quality studies on Bigfoot Creek have consistently shown high levels of total phosphorus, total Kjeldahl nitrogen, ammonia, and iron, with concerningly low oxygen levels, high chemical and biochemical oxygen demand, and turbidity. Several previous studies have investigated the closed Otto Jacobs Landfills as a possible source of contaminants to the Creek. Most recently, the Commission's July 2024 sampling effort strategically included sites upstream, at, and downstream of the Otto Jacobs sites to further investigate the landfill's effect on Bigfoot Creek's water quality. Both previous studies and recent data suggest that the landfills are not likely to be the cause of high iron, total phosphorus and other pollutants within the Creek. In fact, water quality appeared to improve from poor at downstream sites west of the historic landfill sites to more moderate at the sites near the landfills. More specifically total phosphorus, TKN, ammonia, BOD and COD, and iron levels suggested degraded water quality and more pollutant contribution within stretches of the Creek that flowed through the cattail-dominated wetlands north of the Otto Jacobs Landfills.

As previously mentioned, the wetlands surrounding Bigfoot Creek have been shaped by historic land use and invasive emergent aquatic vegetation. Not only can invasive cattail alter wetland vegetation composition and structure, but it can also affect the biogeochemical processes in wetlands.[153] Enhanced nitrogen and phosphorus cycling often occurs in cattail-invaded wetlands due to an increase in decomposing vegetation biomass and nutrient-rich sediment.[154] Furthermore, redox driven iron and phosphorus mobilization, or the releasing of iron and phosphate from sediments into the water under low-oxygen conditions, can be stimulated by this vegetation decomposition processes[155]. Such reactions could partially explain the increased levels of phosphorus and iron observed within the Creek and subsequently the Creek's distinctive orange color. High BOD and COD and low DO within Bigfoot Creek, especially within portions of the Creek that are adjacent to the wetlands, may be explained in part by the large amount of organic matter contributed to the wetland by the cattail and the increased demand for oxygen as this plant

[153] *Bansal, S., Lishawa, S.C., Newman, S. et al. "Typha (Cattail) Invasion in North American Wetlands: Biology, Regional Problems, Impacts, Ecosystem Services, and Management."* Wetlands *39: 645–684, 2019.*

[154] *Bansal, S., Tangen, B., Lishawa, S., Newman, S., and Wilcox, D., 2020*, A review of Cattail (Typha) invasion in North American wetlands: U.S. Geological Survey Fact Sheet *2019.*

[155] *Hogan, D., Jordan, T., Walbridge, M., "Phosphorus Retention and Soil Organic Carbon in Restored and Natural Freshwater Wetlands,"* Wetlands *24: 573-585, 2004.*

biomass is broken down over time. Testing conducted in 2019 and 2020 as part of the Bigfoot Creek Watershed Study aligned with these possible explanations, with the Resource Environmental Solutions 2021 report citing chemical reactions in the drained wetlands and muck soils as the likely cause for elevated phosphorus and iron concentrations in Bigfoot Creek.[156,157]

In conclusion, the water quality issues in Bigfoot Creek appear to stem from a combination of historical land practices and chemical processes naturally occurring within the adjacent degraded wetland system. Additional consideration should be given to future projects that prioritize wetland restoration to improve the ecosystem functions of the wetlands as a means of improving water quality within the Creek.

Birches and Southwick Creeks

Birches and Southwick Creeks were both monitored for streamflow, water temperature, total phosphorus, and total suspended solids by the USGS as part of its 1998 and 1999 water and phosphorus budget for the Geneva Lake watershed.[158] In both streams, both total phosphorus and total suspended solids concentrations and loads were strongly associated with higher streamflow. Baseflow total phosphorus concentrations were reported as typically below 0.07 mg/l while concentrations during runoff events attained 9.0 mg/l and 3.6 mg/l, respectively, in Birches and Southwick Creeks. Sediment followed a similar pattern, with baseflow concentrations of 0.5 and 1.0 g/l and runoff concentrations of 18 and 5.6 g/l in Birches and Southwick Creeks, respectively. The USGS utilized the measurements from these streams to estimate total phosphorus and sediment loads in all ungaged tributaries except for Bigfoot Creek, suggesting that the runoff-driven loading of Birches and Southwick Creeks is likely common behavior across the Lake watershed.

Watershed-Wide Study

In 2021 and 2022, during two six-month periods, water quality parameters were sampled on select Geneva Lake tributaries by UW-Whitewater faculty and students resulting in a report in 2023.[159] The water quality parameters sampled during the study included: total phosphorus, nitrate + nitrite (as N), ammonia, total

[156] *Geneva Lake Environmental Agency, 2020,* op. cit.

[157] *Resource Environmental Solutions, LLC, 2021,* op. cit.

[158] *USGS, 2002,* op. cit.

[159] Splinter, Dale. *A Late Spring-to-Early Fall Examination of Water Quality in Tributaries of the Geneva Lake Watershed: 2021-2022.* University of Wisconsin Whitewater. Submitted to GLC on October 6th 2023.

Kjeldahl nitrogen, total suspended solids, E. coli, water temperature, dissolved oxygen, pH, conductivity, and total dissolved solids. Additionally, stream discharge was calculated at most sampling locations. Between the two years, 18 locations across the watershed were sampled. Tributaries and locations for sampling were selected based on conversations among members of the Water Alliance for Preserving Geneva Lake ("WAPGL"). Tributaries were selected to be a part of the study based on the following criteria:

- if there was pre-existing water quality data available
- if they were perennial
- if they were accessible
- if they had high potential to route nutrients

Of the tributaries sampled, Bigfoot Creek had the highest average total phosphorus with a median concentration of 0.27 mg/l and a maximum concentration of 0.42 observed in August 2022. Abbey Springs had the second highest median concentration at 0.10 mg/l, followed by Simms, Trinke, Birches, and Hillside Creeks with median concentrations ranging from 0.04 to 0.06 mg/l. Many of these tributaries experienced their maximum observed phosphorus concentrations in September 2022, when a significant precipitation event caused substantial runoff during the water quality sampling effort. Total suspended solids for all sites had median concentrations below 30 mg/L, with increases occurring following the September 2022 rain event for many tributaries. These results mirror those observed in the 2002 USGS report, where most of the tributaries had runoff-driven increases in phosphorus and sediment concentrations while Bigfoot Creek had seasonally-driven changes in phosphorus.

For nitrate + nitrite (as N), Gardens, Van Slyke, Potawatomi and Simms had the highest concentrations while Bigfoot, Trinke and Simms had the highest concentrations of ammonia. In addition to atmospheric deposition, these streams are likely among the predominant sources of nitrogen loading to Geneva Lake. Notably, Bigfoot Creek had several months without any detectable nitrate + nitrite concentrations but high concentrations of ammonia, which is likely related to the exceedingly low oxygen concentrations observed in that waterbody (see "Bigfoot Creek" discussion earlier in this section).

Concentrations of *E. coli* were highest in June and August across most of the monitored tributaries in 2021 but were highest in July, August, and September in 2022.[160] There does not appear to be a consistent

[160] *For raw data and additional water quality information on the tributaries sampled see report cited above.*

pattern in the *E. coli* concentrations, with many tributaries exhibiting low concentrations one month and high concentrations the following month that are not explained by changes in temperature or precipitation. Stream *E. coli* concentrations and trends are the subject of further study by the GLEA and UW-Whitewater.

2.5 POLLUTANT LOADING

The most common pollutants entering most lakes are excessive sediment and nutrients. Both occur naturally and are important to lake ecology, but both commonly can be related to human activity. Sediment and nutrients contribute to lake aging. Sediment and nutrient loads can greatly increase when humans disturb land cover and runoff patterns through activities such as tilling and construction, both of which typically loosen soil, increase runoff and in turn allow soil to more easily erode and eventually enter streams and lakes. Drain tiles in agricultural fields have also been shown to export nitrogen and phosphorus from the soil subsurface. In contrast, other pollutants such as detergents, oils, and fertilizers, and certain heavy metals were absent in the environment under natural conditions in Southeastern Wisconsin and are \completely attributable to human activity.

Different human land uses contribute differing pollutants to water bodies. For example, phosphorus in rural areas may be correlated with agricultural fertilizers and animal waste delivered to waterbodies through overland runoff. In contrast, in urban areas, phosphorus from lawn fertilizers, lawn clippings, leaves from ornamental plantings, and cleaning agents are often quickly conveyed to water bodies with little opportunity for attenuation. In 2010, the State of Wisconsin placed restrictions on the sale of some phosphorus-containing cleaning agents.[161] The State has also adopted a turf management standard limiting the application of lawn fertilizers containing phosphorus within the State,[162] potentially helping reduce the amount of phosphorus released from lawns. In both rural and urban areas, poorly maintained or failing onsite wastewater treatment systems have been found to contribute phosphorus to surface water features.

Urban leaf litter and pollen can be a substantial source of phosphorus pollution, particularly in highly developed areas. A study conducted in the Lake Wingra watershed in Dane County found that 55 percent of the total annual residential phosphorus loading occurs during autumn, largely attributable to curbside

[161]*Section 100.28 of the* Wisconsin Statutes *bans the sale of cleaning agents for non-household dishwashing machines and medical and surgical equipment that contain more than 8.7 percent phosphorus by weight. This statute also bans the sale of other cleaning agents containing more than 0.5 percent phosphorus by weight. Cleaning agents for industrial processes and cleansing dairy equipment are specifically exempted from these restrictions.*
[162]*On April 14, 2009,* 2009 Wisconsin Act 9 *created Section 94.643 of the* Wisconsin Statutes *relating to restrictions on the use and sale of fertilizer containing phosphorus in urban areas throughout the State of Wisconsin.*

and street-area leaf litter.[163] Rain falling upon leaves crushed by vehicular traffic leach greater amounts of phosphorus. Runoff then washes the leached phosphorus into the stormwater drainage system that often discharge directly into surface waters. Effectively managing leaves on residential streets can significantly reduce urban phosphorus loading. Preventing leaves from accumulating on the roadway for long periods of time through prompt leaf collection, and especially the timing of that collection from the streets, is a critical part of reducing external phosphorus loading from residential areas. Curbside leaf litter pick up is provided by several municipalities in the Geneva Lake watershed.

Watershed Pollutant Loads

At the present time, most pollutants delivered to the Lake and its tributary streams are carried by runoff and wind. No pollutants are known to be deliberately discharged to the Lake and its tributaries through wastewater discharge points. In-Lake processes are another significant contributor to overall phosphorus loads in many lakes and human activity can intensify their contribution.

The Commission estimated probable pollutant loads, in-lake phosphorous concentrations, and the pollutant reduction from conservation practice implementation using a series of pollutant loading models. Model output can help identify pollutants that could impinge upon the Lake health, land uses and land areas responsible for elevated pollutant loads, and suites of conservation practices that help reduce pollutant loads.

Historical Nutrient Budgets

Pollutant loading to Geneva Lake has been a focus of several previous studies and management plans, including the 1985 first edition of the lake management plan by the Commission, 1994 study by the GLEA and WDNR, a 2002 study by the USGS, and the second edition of the lake management plan published in 2008 by the Commission.[164,165,166] Early pollutant loading studies identified that atmospheric deposition and contributions from perennially flowing tributaries were the primary sources of nitrogen to the Lake while urban runoff, malfunctioning septic systems, atmospheric deposition, and seepage from the

[163] *Roger Bannerman of the USGS has described the findings of the Lake Wingra study in his presentation entitled* "Urban Phosphorus Loads: Identifying Sources and Evaluating Controls."

[164] *Geneva Lake Environmental Agency,* The Use of the AGNPS Model Within the Geneva Lake Watershed, Walworth County, Wisconsin*, March 1994*

[165] *USGS, 2002,* op. cit.

[166] *SEWRPC, 2008,* op. cit.

discontinued Fontana-on-Geneva Lake sewage treatment plant were the primary phosphorus sources.[167] The 1994 study evaluated modeled pollutant loading from three perennial tributaries to the Lake: Bigfoot, Birches, and Southwick Creeks. Southwick Creek was identified as the largest source of sediment and sediment-bound phosphorus and nitrogen to Geneva Lake while Birches Creek was identified as the source of the highest soluble nutrient loads to the Lake.[168]

As described in a 2002 report, the USGS and GLEA constructed a water and phosphorus budget for Geneva Lake using a mixture of streamflow and total phosphorus concentration measurements at monitored tributaries (Bigfoot, Birches, and Southwick Creeks) and estimated values for inputs from ungaged tributaries, septic systems, and waterfowl. The 2002 USGS reported phosphorus loads of 7,000 pounds in the 1998 water year and 18,700 pounds in the 1999 year, with tributaries contributing an average of 85 percent of the phosphorus load.[169] Much of the additional phosphorus load was attributed to precipitation-driven runoff events, which caused significant loading to occur in Birches Creek and was estimated in the unmonitored tributaries across the watershed. Of the three monitored tributaries, Bigfoot Creek had the highest phosphorus loads during the drier 1998 water year, likely due to its high phosphorus concentrations during baseflow, while Birches Creek, which had high phosphorus concentrations during runoff events, had the highest phosphorus loads during the 1999 water year by a significant measure. Croplands were the predominant source of tributary loading at 37.2 percent, followed by forest at 23.2 percent, moderate intensity urban at 13.2 percent, pasture at 10.2 percent, and all remaining land uses at a combined 15.6 percent. Septic systems were estimated to contribute less than three percent of the phosphorus load while waterfowl were estimated to contribute approximately twelve percent.

The 2008 lake management plan estimated phosphorus and sediment loads to the Lake utilizing land use based models with the Commission's 2000 land use inventory of the watershed.[170] The total phosphorus load was estimated as 6,974 pounds, with mixed agriculture contributing 46.4 percent of the load followed by atmospheric deposition to the lake surface at 20.2, and urban land use at 18.9 percent. This plan estimated a total sediment load of 3,449,816 pounds with agricultural land uses contributing nearly 60 percent of this load and atmospheric deposition of sediment to the lake surface contributing nearly 30

[167] *Ibid.*

[168] *GLEA, 1994,* op. cit.

[169] *USGS, 2002,* op. cit.

[170] *SEWRPC, 2008,* op. cit.

percent. However, this plan notes that only 50 percent of the sediment loading is actually delivered to the lake, resulting in a delivered sediment load of 1,725,000 pounds.

Simulated Nonpoint Source Loads

The Commission simulated current nonpoint source pollutant loads using two land-use based models: the Pollutant Load Ratio Estimation Tool (Presto-Lite) and the Wisconsin Lake Modeling Suite (WiLMS). Each of these models assume that a given land use type emits a set rate of pollutants on an annual basis. However, each model incorporates different elements and has different base assumptions, resulting in similar but not matching pollutant load outputs for the same watershed.

Presto-Lite Modeled Loads

The Presto-Lite tool delineates a watershed, summarizes the land cover within that watershed, and estimates the non-point source and point source originating phosphorus loads for the watershed.[171] Commission staff utilized the WDNR Wisconsin Water Explorer (WEx) to simulate Presto-Lite for the Geneva Lake watershed, as defined in the WEx tool. Presto-Lite delineated a 28.5 square-mile watershed for the entire lake and estimated an average annual nonpoint source phosphorus load of 10,340 pounds with an 80 percent confidence interval of 5,092 to 21,067 pounds. The model indicated zero permitted industrial and municipal discharging facilities within the watershed so there are zero pounds of phosphorus from point sources entering the lake. Commission staff also used the model to estimate phosphorus loading for individual tributaries across the lake watershed (see Map 2.7 for tributary numbers in parentheses):

- Alta Vista Creek (44): 779 pounds (361 – 1,680 pounds)
- Bigfoot Creek (8): 420 pounds (178 – 987 pounds)
- Birches Creek (17): 796 pounds (405 – 1,564 pounds)
- Chapin Creek (50): 93 pounds (44 – 194 pounds)
- Country Club Creek (16): 571 pounds (292 – 1,119 pounds)
- Covenant Harbor Creek (2): 66 pounds (30 – 159 pounds)
- Elgin Club Creek (42): 154 pounds (74 – 319 pounds)
- Gardens Creek (37): 408 pounds (208 – 800 pounds)
- Geneva Bay Estates Creek (1): 806 pounds (384 – 1,693 pounds)

[171] See the WDNR description of the Presto-Lite model at the following link: https://dnr.wisconsin.gov/topic/SurfaceWater/PRESTO.html

- Glen Fern Creek (43): 241 pounds (102 – 570 pounds)
- Harris Creek (40): 17 pounds (8 – 38 pounds)
- Indian Hills Creek (30): 47 (23 – 97 pounds)
- Lake-direct tributaries: 3,064 pounds (1,560 – 6,017 pounds)
- Loramoor Creek (12): 268 pounds (136 – 530 pounds)
- Potawatomi-Van Slyke Creeks (31A and 31B): 221 pounds (98 – 500 pounds)
- Rasin Creek (46): 298 pounds (150 – 592 pounds)
- Simms Creek (22): 95 pounds (48 – 188 pounds)
- Trinke Creek (15): 1,940 pounds (964 – 3,905 pounds)
- Yacht Club Creek (25): 56 pounds (27 – 115 pounds)

WiLMS Modeled Loads

The WiLMS model uses land use, hydrologic, and watershed area information to estimate the total flux of phosphorus to a lake during a typical year.[172] The WiLMS model produces a range of probable phosphorus loads (low, most likely, and high) that are based on the land use, number of septic systems, and wastewater inputs within the lake watershed. With these phosphorus loads, WiLMS then predicts the total phosphorus concentrations in the receiving lake using regression equations that have been designed to fit a variety of lake types (e.g., deep lakes, reservoirs, and general lake models). The USGS has found that pollutant loading models tend to over-predict phosphorus values for hardwater lakes (such as Geneva Lake). Given the significance of carbonate-induced phosphorus sequestration in hardwater lakes, this seems reasonable. For this reason, the WiLMS low range phosphorus loading estimate is believed to best portray local conditions.

Commission staff set up the WiLMS model using WEx to predict phosphorus loading to Geneva Lake. The default watershed land use for the model (derived from the 2006 National Land Cover Dataset) was modified to match the 2020 watershed land use as determined by the Commission. Additionally, Commission staff estimated the septic system inputs to the lake by using an estimated number of septic systems in the watershed, the estimated phosphorus loss from those systems, and the soil phosphorus retention

[172] *These models do not account for groundwater influx and exit from the lake. Models can be adjusted to include this variable if sufficient interest is expressed by lake users and managers as part of a future study. Groundwater is an important component of the water budget of Geneva Lake. Including groundwater in future models may not necessarily improve the accuracy of the models, but will account for and potentially eliminate a currently untested variable from the simulation process.*

capacity.[173] There are no wastewater inputs within the lake watershed. Under these conditions, the WiLMS model predicts between 3,070 and 15,751 pounds of phosphorus could be delivered to Geneva Lake each year from nonpoint sources, with the most likely value at 6,125 pounds per year. Of the 6,125 pounds per year, 95 percent is contributed from the watershed land uses while 5 percent is contributed from septic systems. Of the watershed land uses, the model estimates that 2,910 pounds (37.6 percent) are from row crop agriculture, 1,450 pounds (24.9 percent) are from atmospheric deposition to the lake surface, 539 pounds (9.2 percent) are from urban land uses (including residential uses), and 924 pounds (15.9 percent) are from wetlands, woodlands, and other land uses.

Commission staff also used WiLMS to individually model the select tributaries that are mapped by WDNR and permitted using the Water Explorer tool.[174] Of these tributaries, Bigfoot Creek was estimated to have the highest phosphorus loading at 781 pounds per year and was closely followed by Birches Creek at 774 pounds per year. The loading from other modeled tributaries was largely proportional to their contributing watershed area and ranged from 8 to 241 pounds per year. Loading rates, expressed in pounds of phosphorus per acre, ranged from approximately 0.14 to 0.59 pounds per acre, with subwatersheds that have a higher percentage of agricultural lands, such as Bigfoot and Birches Creeks, having a higher phosphorus loading rate than subwatersheds with more residential or natural land covers, such as Harris Creek.

Commission staff used the watershed modeled phosphorus load in WiLMS to predict water quality in the Geneva Lake using regression equations that have been designed to fit a variety of lake types (e.g., deep lakes, reservoirs, and general lake models). The Reckhow 1979 general model best fits observed conditions in Geneva Lake as the predicted surface water phosphorus concentrations (0.009 mg/l) most closely matched average concentrations (0.010 mg/l) in the Lake. WiLMs model outputs suggest that before settlement, Geneva Lake's phosphorus concentrations averaged around 0.05 mg/l, suggesting that the Lake was an oligotrophic waterbody. With the Reckhow model for the lake, a 20 percent reduction in phosphorus

[173] The USGS estimated a total of 1,200 septic systems in the Geneva Lake watershed in its 2002 report based on records from the Linn Sanitary District and permits from Walworth County.

[174] Southwick Creek and many other tributaries are not able to be individually modeled using the Water Explorer tool and consequently should be considered within the lake-direct tributary load, which was approximately 51 percent of the modeled phosphorus load.

loading would result in a lake concentration of 0.007 mg/l while a 50 percent reduction would be necessary to attain likely pre-settlement concentrations of 0.05 mg/l.

In-Lake Phosphorus Sources

Internal Loading

Phosphorus concentrations tend to vary widely in the deepest parts of the Lake. As shown in Figure 2.17, samples drawn from the Lake's deep water hypolimnion during the summer months commonly contain phosphorus concentrations more than ten times higher than that in the epilimnion. Large discrepancies between surface and deep water phosphorus concentrations are an indication of internal loading. Under oxygenated conditions, phosphorus remains tightly bound to lake-bottom sediment; however, during anoxic conditions, geochemical reactions release this phosphorus from the bottom sediment into the water column where it is then free to mix throughout the entire water column during the next overturn period. Phosphorus released in stratified lakes in this condition is a well-documented phenomenon and can account for up to 39 percent of a lake's total phosphorus load.[175]

Exposure of sediment to anoxic water can exacerbate internal loading issues. When anoxic conditions are present, the amount of exposed sediment is influenced by the shape of the lake basin. Even though two lakes may have equivalent maximum depths, a lake that has broad shallow areas and a small deep hole has less deep water bottom sediment area than an equal depth lake that is uniformly deep. Since sediment exposed to anoxic water can release phosphorus into the water column, lakes with more deep water sediment area are more susceptible to significant phosphorus internal loading. Moderate depth/size stratified lakes are among the most prone to internal phosphorus loading. Such lakes lack large water volumes, and, hence, have comparatively little stored oxygen in the hypolimnion, making them prone to anoxia. As discussed in Section 2.4, "Water Quality," late summer and early fall anoxia forms in Geneva Lake below 120 feet depth in September and early October in many years, resulting in about 118 acres of anoxic lake bottom that could contribute to internal phosphorus loading (see Figure 2.12 and Figure 2.17).

To evaluate the contribution of internal loading to total Lake phosphorus loads, Commission staff calculated the internal loading rate for Geneva Lake using the difference in spring and summer hypolimnetic

[175]*G.K. Nurnberg, and R.H. Peters, "The Importance of Internal Phosphorus Load to the Eutrophication of Lakes With Anoxic Hypolimnia: With 8 Figures in the Text,"* Verhandlung Internationale Vereinigung Limnologie*, 22(1): 90-194, 1984.*

phosphorus concentrations multiplied by the volume of anoxic water within the Lake. This calculation assumes that the hypolimnetic phosphorus concentrations are entirely driven by release of phosphorus from lake-bottom sediment, which may be an overestimation of these rates. The spring hypolimnetic mean total phosphorus concentration was 0.012 mg/l while the summer mean concentration was 0.020 mg/l. Using these mean concentrations and a typical anoxic volume of 690-acre feet, the internal loading rate for the Lake is approximately 150 pounds per year. As the hypolimnetic phosphorus concentration has increased over time, it is possible that the Lake's internal loading has also increased and will become a more important component of the Lake's phosphorus budget if these concentrations continue to increase.

Internal Recycling

Another process that can contribute significantly to a lake's phosphorus load is internal recycling. As rooted aquatic plants grow, they take up phosphorus from the lake sediment through their roots and incorporate it into their tissue.[176] When the plant dies and decays, this phosphorus can then be released back into the water column. In a study done on Lake Wingra in Madison, Wisconsin,[177] internal recycling of Eurasian watermilfoil (*Myriophyllum* spicatum) represented 47 percent of the annual phosphorus input to the lake. In a study conducted on Whitewater and Rice lakes in 1991,[178] internal recycling was found to account for approximately 51 percent of the combined internal and external total phosphorus input to Whitewater Lake, equivalent to 582 pounds of phosphorus, and 82 percent of the total to Rice Lake, equivalent to 295 pounds of phosphorus. According to this study, "at Whitewater Lake, by late July, in-lake phosphorus mass had exceeded inputs by a factor of more than 3, and at Rice Lake, the in-lake phosphorus mass had exceeded the external inputs by a factor of more than 13." Just how important recycling of phosphorus is in Geneva Lake has yet to be determined and would require a separate study beyond the scope of this report.

There are other minor events and processes related to physical disruption of bottom sediments, especially in shallow lakes, that can cause phosphorus levels in a lake's water column to increase: movement through sediment by benthic organisms, propeller-caused stirring of bottom sediments by motorboats, and

[176] *Other aquatic plants, particularly free-floating plants like duckweeds (*Lemna *spp.), absorb all their nutrients from the water column directly.*

[177]*C.S. Smith and M.S. Adams, "Phosphorus Transfer From Sediments by Myriophyllum spicatum,"* Limnology and Oceanography, *31(6): 1312-1321, 1986*.

[178]*G.L. Goddard and S.J. Field,* Hydrology and Water Quality of Whitewater and Rice Lakes in Southeastern Wisconsin, 1990-91, *U.S. Geological Survey Water-Resources Investigations Report 94-410, 1994.*

wind/wave action. Such physical disruptions tend to re-suspend bottom sediments and cause phosphorus concentrations in the water column to increase. The impacts of boat wakes on sediment resuspension is discussed in Section 2.8, "Recreational Use."

2.6 AQUATIC PLANTS

Aquatic plant management is a visible and well-known concern for Lake residents and users. This section first examines the general need for aquatic plant management by quantifying the current state of aquatic plants in Geneva Lake. The most recent aquatic plant survey is then compared to past aquatic plant surveys. Lastly, management techniques are discussed that are appropriate given the Lake's physical conditions and ecosystem.

It is important to note that all healthy lakes have plants. In fact, in a lake such as Geneva Lake, it is normal to have luxuriant plant growth in shallow areas where sunlight is able to reach the lakebed. Native aquatic plants form a foundational part of a lake ecosystem. Aquatic plants form an integral part of the aquatic food web, converting sediments and inorganic nutrients present in the water into organic compounds that are directly available as food to other aquatic organisms. In this process, known as *photosynthesis*, plants utilize energy from sunlight and release the oxygen required by many other aquatic life forms into the water. Aquatic plants also serve a number of other valuable functions in a lake ecosystem, including:

- Improving water quality and suppressing algal growth by using excess nutrients
- Providing habitat for invertebrates and fish
- Stabilizing lake bottom sediments
- Supplying food and oxygen to the lake through photosynthesis

A lake's water clarity, configuration, depth, nutrient availability, wave action, and fish population assemblage affect the abundance, diversity, and distribution of aquatic plants. Given the importance of native aquatic plants to overall lake health, it is desirable to periodically re-examine the abundance, distribution, and diversity of aquatic plants. Such data is contrasted to historical conditions in the Lake itself and other similar lakes; both comparisons help quantify the overall health of the aquatic plant community. A judgement can subsequently be made regarding the need for active aquatic plant management, and the locations and methods that provide the most overall apparent benefit to the Lake's health and user needs can be identified.

Phytoplankton, Algae, and Macrophytes

Aquatic plants include microscopic algae ("phytoplankton") and larger plants ("macrophytes"). Phytoplankton is the term for a group of microscopic organisms that includes bacteria, protists, and algae. These organisms are aquatic and can all actively photosynthesize. Maintaining a healthy community of phytoplankton is essential for lake health, as these species form the foundation of the lake's food web and create oxygen required by other organisms, such as zooplankton and fish. However, an overabundance of phytoplankton, generally caused by excessive nutrient loads, can impair lake health by decreasing water clarity and reducing hypolimnetic oxygen. Since phytoplankton and macrophytes compete for nutrients, an abundance of macrophytes means fewer nutrients (usually phosphorus) available to algae, in turn reducing the abundance of free-floating algae and increasing water clarity.

Algae is a foundational component of lake food chains and produces oxygen in the same way as rooted plants. Many kinds of algae exist, from single-cell, colonial, and filamentous algae to cyanobacteria. Most algae strains are beneficial to lakes when present in moderate levels. However, the presence of toxic strains, as well as excessive growth patterns, should be considered issues of concern. As with aquatic plants, algae grows faster in the presence of abundant phosphorus (particularly in stagnant areas). Consequently, when toxic or high volumes of algae begin to grow in a lake, it often is a sign of phosphorus enrichment or pollution. There have been periodic toxic algal blooms in Geneva Lake documented as recently as summer 2024.

Macrophytes are often described using the terms *submerged, floating-leaf, free-floating,* and *emergent,* depending on where the plant is found in the lake ecosystem. *Submerged* plants are found in the main lake basin and, although most are rooted in the bottom substrate, some species, such as coontail (*Ceratophyllum demersum*) can become free-floating. *Floating-leaf* plants, such as water lilies, generally have large, floating leaves and are usually found in shallow water areas a few feet in depth or less that contain loose bottom sediments. *Free-floating* plants, such as duckweed (*Lemna* spp.), have small leaves, are not rooted to the sediment, and are often wind-blown around the waterbody. *Emergent* plants, which have leaves that emerge above the water, are commonly found along the shoreline areas of a lake, such as bulrushes and cattails. All four types have significant roles to play in the overall working of a lake's ecosystem.

Aquatic plants live in community with one another. They develop complex interactions and mutual dependencies that are of great significance in how these dynamic communities function within a lake. Native aquatic plant species are specifically adapted to local aquatic environments and many kinds of wildlife depend on the presence of specific native plant species for survival. For example, the seeds and tubers of Sago pondweed (*Stuckenia pectinata*) are an important food source for migratory waterfowl. In Wisconsin, the presence of native pondweeds is generally considered to be indicative of a healthy lake with good habitat for fish and aquatic life. Pondweeds provide good habitat and serve as food and shelter for a variety of aquatic organisms and waterfowl. For example, within Geneva Lake the highest numbers of nearshore fish species richness and abundance collected in 2023 were generally associated with the highest diversity, quality, and abundance of aquatic plant community nearshore areas of the Lake in 2024.

Maintaining a rich and diverse community of native species is important for every ecosystem as this:

- Helps sustain and increase the robustness of the existing system
- Increases the ability of an ecosystem to adapt to environmental changes
- Provides a spectrum of options for future decisions regarding the management of that system

Many factors—including lake configuration, depth, water clarity, nutrient availability, bottom substrate, wave action, and type and size of fish populations—determine the distribution and abundance of aquatic macrophytes in lakes, with most waterbodies within Southeastern Wisconsin naturally supporting abundant and diverse aquatic plant communities.

Aquatic Plants in Geneva Lake

It is pertinent to know that in the 2023 Lake User Survey sent out by GLC, nearly 85 percent of respondents indicated that excessive aquatic plant growth has either some impact or a large impact on the Lake.[179]

Aquatic Plant Surveys

There have been several historical aquatic plant inventories completed on the Lake, with the earliest in 1967 and the most recent in 2024. These surveys were conducted using a variety of methods. The 1967 survey was conducted by the WDNR by reviewing aerial imagery as well as conducting reconnaissance on the

[179] *2023 Geneva Lake User Survey. Geneva Lake Conservancy, 2023.*

lake.[180] The 1976, 1994, and 2001 surveys were conducted using a transect approach. The 1976 survey had 627 sampling sites along 107 transects with the 1994 survey sampling along every-other transect, a total of 55, with approximately 4 sampling sites per transect. The 2015, 2019, 2020, 2022, and 2024 surveys were conducted using a point-intercept approach.[181] The point-intercept method uses predetermined sampling sites arranged in a grid pattern across the entire lake surface (see Figure 2.27); each site is located using global positioning system (GPS) technology. At each site, a single rake haul is taken and a qualitative assessment of the rake fullness, on a scale of zero to three, is then made for each species identified (see Figure 2.28).

In addition to whole lake inventories, there have also been surveys targeting specific areas and species within the lake. Following the discovery of starry stonewort (*Nitellopsis obtusa*, "SSW") in Trinke Lagoon, three sets of sub-point-intercept (sub-PI) surveys have been conducted to investigate the distribution of this species around the Lake. The WDNR conducted sub-PI surveys in 2018 near private and public launches to determine whether SSW was present in any other areas of the lake and to inform potential control measures to reduce spread to other lakes. In 2021 and 2023, the GLEA contracted the Commission to conduct sub-PI surveys using modified versions of the 2018 survey grids; forked duckweed (*Lemna trisulca*) was also identified as a species of concern in the 2023 surveys. The results of these sub-PI surveys will be discussed in more detail in the "Starry Stonewort" sub-section later in this chapter.

Aquatic Plant Survey Metrics

Total Rake Fullness

Surveyors qualitatively rated the plant abundance at each survey point by how much of the sampling rake was covered by all aquatic plant species.[182] This rating, called total rake fullness, can be a useful metric evaluating general abundance of aquatic plants as part of the point-intercept survey. As shown in Figure 2.28, total rake fullness across all surveyed points in Geneva Lake averaged 1.24 in 2024 which is down from 2022 where the average rake fullness was 1.37. '

[180] *Wisconsin Department of Natural Resources, 1969*, op. cit.

[181] *Further details on the methodology can be found in Wisconsin Department of Natural Resources, Publication No. PUB-SS-1068,* Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry and Analysis, and Applications*, 2010*

[182] *This method follows the standard WDNR protocol.*

Maximum Depth of Colonization

Maximum depth of colonization (MDC) can be a useful indicator of water quality, as turbid and/or eutrophic (nutrient-rich) lakes generally have shallower MDC than lakes with clear water.[183] It is important to note that for surveys using the point-intercept protocol, the protocol allows sampling to be discontinued at depths greater than the maximum depth of colonization for vascular plants. However, aquatic moss and macroalgae, such as muskgrass and nitella (*Nitella* spp.), frequently colonize deeper than vascular plants and thus may be under-sampled in some lakes. For example, *Chara globularis* and *Nitella flexilis* have been found growing as deep as 37 feet and 35 feet, respectively, in Silver Lake, Washington County.

In Geneva Lake, the MDC has ranged between 27.0 feet (2022) and 41.6 feet (2015) (see Table 2.10). Many of the plant observations deeper than 20 feet in these surveys were of muskgrass, coontail, and the nonnative starry stonewort (*Nitellopsis obtusa*). Based on the decreasing MDC over time, water clarity appears to be decreasing over time between 2015 and 2024. This trend appears to be in opposition to the trend of increasing water clarity in the past few years. Continued aquatic plant monitoring should reveal whether the aquatic plant community responds to the increased water clarity by colonizing deeper areas of the Lake.

Species Richness

The number of distinct types of aquatic plants present in a lake is referred to as the *species richness* of the lake. Larger lakes with diverse lake basin morphology, less human disturbance, and/or healthier, more resilient lake ecosystems have greater species richness. Aquatic plants provide a wide variety of benefits to lakes, examples of which are briefly described in Table 2.11.

The observed species richness of Geneva Lake has varied throughout the plant surveys between 1967 and 2024 (see Figure 2.29), which may reflect cyclical changes in the aquatic plant population as well as differences between individual surveyors (see Table 2.12).[184] Some species observed in earlier surveys were not observed during the 2024 survey; however, some of species recorded in earlier surveys are exceptionally rare aquatic plant species that may have been misidentified in that survey or this may represent a loss of

[183] *D.E. Canfield Jr, L. Langeland, and W.T. Haller, "Relations Between Water Transparency and Maximum Depth of Macrophyte Colonization in Lakes,"* Journal of Aquatic Plant Management *23, 1985.*

[184] *The 1967 aquatic plant survey only identified six genera of aquatic plants within the Lake and no plants were identified to species. Consequently, the results from this survey are excluded from Table 2.12.*

these species.[185] Forty-one different aquatic plant species have been recorded in Geneva Lake since it was first surveyed in 1976. Each time the Lake has been surveyed an average of 27 plant species have been found. Three of those species are nonnative aquatic plants, Eurasian watermilfoil, curly-leaf pondweed, and starry stonewort, which are discussed in further detail in the following sections.

Species richness is often incorrectly used as a synonym for biodiversity. The difference in meaning between these terms is both subtle and significant. Biodiversity is based on the number of species present in a habitat along with the abundance of each species. Current point-intercept survey protocol calculates abundance as the percentage of observations of each species compared to the total number of observations made. Aquatic plant biodiversity can be measured with the Simpson Diversity Index (SDI).[186] Using this measure, a community dominated by one or two species would be considered less diverse than one in which several different species have similar abundance. In general, more diverse biological communities are better able to maintain ecological integrity in response to environmental stresses. Promoting biodiversity not only helps sustain an ecosystem but preserves the spectrum of options useful for future management decisions. Of the four surveys done on Geneva Lake in the last 10 years, all the results indicated that the Lake has a SDI of 0.9 or slightly higher.[187] An SDI value closer to 1.0 indicates a healthier and more evenly spread plant community across the lake.

Sensitive Species

Aquatic plant metrics, such as species richness and the floristic quality index (FQI), can be useful for evaluating lake health. In hard water lakes, such as those common in Southeastern Wisconsin, species richness generally increases with water clarity and decreases with nutrient enrichment.[188] The FQI is an assessment metric used to evaluate how closely a lake's aquatic plant community matches that of undisturbed, pre-settlement conditions.[189] To formulate this metric, Wisconsin aquatic plant species were

[185] *Unfortunately no voucher specimens were saved from these early surveys, so it is not possible to verify these species records.*

[186] *The SDI expresses values on a zero to one scale where 0 equates to no diversity and 1 equates to infinite diversity. Within Southeastern Wisconsin, lakes with exceptionally poor aquatic plant diversity have SDI values near 0.5 while lakes with the highest diversity have SDI values exceeding 0.9.*

[187] *See Table 1 in the Geneva Lake 2022 Aquatic Plant Survey Report. Wisconsin Lake & Pond Resource LLC..*

[188] *Vestergaard, O. and Sand-Jensen, K. "Alkalinity and Trophic State Regulate Aquatic Plant Distribution in Danish Lakes,"* Aquatic Botany *67, 2000.*

[189] *S. Nichols, "Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications,"* Lake and Reservoir Management *15(2), 1999.*

assigned conservatism (C) values on a scale from zero to ten that reflect the likelihood that each species occurs in undisturbed habitat. These values were assigned based on the species substrate preference, tolerance of water turbidity, water drawdown tolerance, rooting strength, and primary reproductive means. Native "sensitive" species that are intolerant of ecological disturbance receive high C values, while natives that are disturbance tolerant receive low C values. Invasive species are assigned a C value of 0. A lake's FQI is calculated as the average C value of species identified in the lake, divided by the square root of species richness. The Lake's FQI in 2015 was 37.14 while the 2024 FQI was 29.40 (see Table 2.13). All point-intercept surveys had higher FQI values than the 20.0 average FQI for the Southeastern Wisconsin Till Plains ecoregion, indicating that the Lake supports species that are more sensitive to ecological disturbance than the average lake in the Region.

The WDNR currently uses an aquatic plant bioassessment method published by Mikulyuk et al., 2017 to assess whether lakes should be listed on the 303(d) impaired waters list. This method identifies species that are tolerant, moderately tolerant, and sensitive to human disturbance. Thirteen different sensitive species have been found over the years (see Table 2.12). Three sensitive species, as identified in this methodology, were found during the 2024 survey: slender naiad (*Najas flexilis*), large-leaf pondweed (*Potamogeton amplifolius*), and variable pondweed (*Potamogeton gramineus*).[190] The number of sensitive species identified at each survey point are shown in Figure 2.30.

Relative Species Abundance

Based on the 2024 point-intercept survey, the five most abundant submerged aquatic plant species in the Lake were, in decreasing order of abundance: 1) common stonewort (*Chara contraria*), 2) coontail (*Ceratophyllum demersum*), 3) sago pondweed (*Stuckenia pectinata*), 4) Fries pondweed (*Potamogeton friesii*), and 5) slender nitella (*Nitella flexilis*). The distribution of the most common aquatic plant species identified as part of the 2023 survey is mapped in Appendix B. The on-average most common plants each year in Geneva Lake and their frequency of occurrence can be seen in Figure 2.31.

Apparent Changes in Observed Aquatic Plant Communities

This section will summarize key takeaways regarding the changes in the aquatic plant community in Geneva Lake (see Table 2.13).

[190] *Mikulyuk, A.M., et al., "A Macrophyte Bioassessment Approach Linking Taxon-Specific Tolerance and Abundance in North Temperate Lakes,"* Journal of Environmental Management *199: 172-180, 2017.*

- Of the 2,685 sampling points on Geneva Lake, around 30 percent of the sites have conditions favorable for aquatic plant growth. The maximum depth where plants have been found has ranged from 27 to 41.6 feet over the last ten years and four aquatic plant surveys.
- On average over the previous five aquatic plant surveys, wild celery, coontail, ditch grass, forked duckweed and muskgrass have been the dominant native plant species found in the lake over time (see Figure 2.31). Throughout this period, the littoral frequency of occurrence for these species has been largely steady with the exception of forked duckweed.
- In the last 10 years forked duckweed's frequency of occurrence has greatly increased to a nuisance level in some years (see Figure 2.32). This rapid increase in forked duckweed within the Lake observed during full point-intercept surveys, from 5.8 percent of the littoral points in 2015 to 38.45 percent in 2024, may indicate increasing nutrient availability in the Lake as this species readily uptakes bioavailable phosphorus and nitrogen in the water column. While this response does benefit the lake's water quality, this increased growth does present a concern about the increasing trophic status of Geneva Lake.
- The population of starry stonewort has increased from 0.3 percent of littoral points in 2019 to 0.94 percent of littoral points in 2024. Although the coverage by this species is still low, the species can be found in a variety of aquatic habitats on the lake (see "Starry Stonewort" section later in this chapter).
- The EWM population has fluctuated with observations between 12 and 26 percent of littoral points since 2015. These fluctuations represent natural changes in the population in response to environmental changes and competition from other aquatic plant species as there is no whole-lake aquatic plant management for this species.
- Northern watermilfoil (*Myriophyllum sibiricum*) has markedly declined from approximately 17 percent in 2015 to less than one percent in 2014. This decline may be due in part to increased hybridization with invasive EWM.
- Several native large pondweeds, such as large-leaf pondweed (*Potamogeton amplifolius*), Illinois pondweed (*P. illinoensis*), white-stem pondweed (*P. praelongus*), and clasping-leaf pondweed (*P. richardsonii*) appear to have consistent but small populations within the lake and consequently are not identified in every aquatic plant survey. These species provide important habitat for predatory fish but may be easily damaged by boat traffic in shallow waters.

Invasive Aquatic Plants

Geneva Lake has documented populations of several nonnative aquatic plant species. The biology of these plants and their history in Geneva lake are outlined below.

Eurasian Watermilfoil

EWM is one of eight milfoil species found in Wisconsin and is the only exotic or nonnative milfoil species. EWM favors mesotrophic to moderately eutrophic waters, fine organic-rich lake-bottom sediment, warmer water with moderate clarity and high alkalinity, and tolerates a wide range of pH and salinity.[191,192] In Southeastern Wisconsin, EWM can grow rapidly and has few natural enemies to inhibit its growth. Furthermore, it can grow explosively following major environmental disruptions, as small fragments of EWM can grow into entirely new plants.[193] For reasons such as these, EWM can grow to dominate an aquatic plant community in as little as two years.[194, 195] In such cases, EWM can displace native plant species and interfere with the aesthetic and recreational use of waterbodies. However, established populations may rapidly decline after approximately ten to 15 years.[196]

Human produced EWM fragments (e.g., created by boating through EWM), as well as fragments generated from natural processes (e.g., wind-induced turbulence, animal feeding/disturbance) readily colonize disturbed sites. contributing to EWM spread. EWM fragments can remain buoyant for two to three days in summer and two to six days in fall, with larger fragments remaining buoyant longer than smaller ones.[197] The fragments can also cling to boats, trailers, motors, and/or bait buckets where they can remain alive for weeks contributing to transfer of milfoil to other lakes. For these reasons, it is especially important to remove

[191]*U. S. Forest Service, Pacific Islands Ecosystems at Risk (PIER), 2019.: hear.org/pier/species/myriophyllum_spicatum.htm*

[192]*S.A. Nichols and B. H. Shaw, "Ecological Life Histories of the Three Aquatic Nuisance Plants: Myriophyllum spicatum, Potamogeton crispus, and Elodea canadensis,"* Hydrobiologia *131(1), 1986.*

[193]*Ibid.*

[194]*S.R. Carpenter, "The Decline of Myriophyllum spicatum in a Eutrophic Wisconsin (USA) Lake,"* Canadian Journal of Botany *58(5), 1980.*

[195]*Les, D. H., and L. J. Mehrhoff, "Introduction of Nonindigenous Vascular Plants in Southern New England: a Historical Perspective,"* Biological Invasions *1: 284-300, 1999.*

[196]*S.R. Carpenter, 1980, op. cit.*

[197]*J.D. Wood and M. D. Netherland, "How Long Do Shoot Fragments of Hydrilla (Hydrilla verticillata) and Eurasian Watermilfoil (Myriophyllum spicatum) Remain Buoyant?", Journal of Aquatic Plant Management 55: 76-82, 2017.*

all vegetation from boats, trailers, and other equipment after removing them from the water and prior to launching in other waterbodies.

The earliest documented population of EWM in Geneva Lake was in 1976 and EWM has been observed in every aquatic plant survey since that time. As of the 2024 survey, EWM was found at 199 points, primarily in the eastern basin of the Lake (see Figure 2.33). Over the last five aquatic plant surveys, EWM has averaged a littoral frequency of occurrence of 20 percent (see Table 2.13).

Curly-Leaf Pondweed

Curly-leaf pondweed is the only non-native pondweed found within Wisconsin. This species is predominantly found in disturbed, eutrophic lakes, where it exhibits a peculiar split-season growth cycle that provides a competitive advantage over native plants and makes management of this species difficult. This species reproduces using turions, a type of plant bud found in some aquatic plants. Turions are produced in late summer, lie dormant in lake sediment, and germinate during cooler weather in fall. Over the winter, the turions produce winter foliage that thrives under the ice. In spring, when water temperatures begin to rise again, the plant has a head start on the growth of native plants and quickly grows to full size, shading the lake bottom and producing flowers and fruit earlier than its native competitors. CLP begins to senesce in midsummer, increasing lake water phosphorus concentrations during warm weather. This can cause excessive growth of other plants and algae and can reduce lake water quality. CLP can grow in more turbid waters than many native plants. Therefore, protecting or improving water quality is an effective method of control of this species, as clearer waters in a Lake can help native plants compete more effectively.

CLP populations have been verified in Geneva Lake since November 1939. Most recently in 2024, CLP was found at only 3 sample points across the lake (see Figure 2.34). Comparatively, in 2015 it was found at 34 sample points and has declined steadily since then.

Starry Stonewort

Starry stonewort is a novel aquatic invasive macroalga species in Wisconsin. As a member of the Characeae, SSW ("SSW") is related to native *Chara*, *Lychnothamnus*, *Nitella*, and *Tolypella* species, which have roughly similar characteristics and are found in many hardwater lakes across Wisconsin. Native to Eurasia, the first discovery of SSW in North America was in the St. Lawrence Seaway in 1978; it has since spread to several northeastern and midwestern US states as well as southern Ontario.[198] First observed within Wisconsin in Little Muskego Lake during September 2014, SSW has since been found in 17 lakes in Southeastern Wisconsin.[199]

In its native range, SSW has been shown to provide food and habitat for aquatic organisms as well as enhance lake water quality by reducing sediment suspension and acting as a phosphorus sink.[200] In invaded lakes, SSW can form dense beds, with reported maximum heights of 4 to 7 feet, outcompete both native and other invasive plant species, and cover fish spawning areas.[201,202,203] This species is capable of both sexual and asexual reproduction, which can occur through plant fragments as well as the star-shaped bulbils for which the species is named.[204] Only male species have been observed in North America thus far, indicating that all spread has been through asexual reproduction. Bulbils may stay viable in lake sediment for several years, making it extremely difficult to eradicate SSW from a waterbody.

SSW was first found in Geneva Lake in August 2018 near Trinke Estates, a private marina on the Lake. Following this discovery, the WDNR conducted a series of sub-PI surveys near launches across the Lake but did not observe any additional SSW populations. In 2019, the GLEA contracted Onterra, LLC to conduct a PI survey of the Lake; during this survey, SSW was observed in a "colony area" of the main lake outside of Trinke Lagoon for the first time. This finding was confirmed by WDNR later that year via a meander survey.

[198] *https://starrystonewort.org/maps/*

[199] *https://apps.dnr.wi.gov/lakes/invasives/AISLists.aspx?species=STARRY_STONEW*

[200] *For a more complete review of SSW ecology in its native and invasive range, see D.J. Larkin, A.K. Monfils, A. Boissezon, R.S. Sleith, P.M. Skawinski, C.H. Welling, B.C. Cahill, and K.G. Karol, "Biology, Ecology, and Management of Starry Stonewort (Nitellopsis obtusa; Characeae): A Red-listed Eurasian Green Alga Invasive in North America,"* Aquatic Botany *148: 15-24, 2018 as well as State of Michigan,* Status and Strategy for Starry Stonewort (Nitellopsis obtusa) *(Desv. In Loisel.) J. Groves) Management, last updated December 2017 (https://www.michigan.gov/documents/invasives/egle-ais-nitellopsis-obtusa-strategy_708937_7.pdf).*

[201] *Ibid.*

[202] *https://dnr.wisconsin.gov/sites/default/files/topic/Invasives/Nitellopsis%20obtusa.pdf*

[203] *G.D. Pullman and G. Crawford, "A Decade of Starry Stonewort in Michigan,"* Lakeline *36-42, 2010.*

[204] *https://dnr.wisconsin.gov/topic/Invasives/fact/StarryStonewort.html*

The Commission conducted sub-PI surveys at launches across the Lake and in the "colony" area in 2021 and 2023. No new populations of SSW were observed in either survey. The average depth of SSW observations within the "colony area" was approximately 17 feet in 2023 compared to an average depth of 13 feet in 2021. Additionally, SSW was found at points further east in 2023 than had been observed in 2021. Starry stonewort abundance was generally low across the observed points in the "colony area," with an average rake fullness of 1.3 and no rake fullness of 3, indicating a rake completely covered in SSW. Multiple native species were observed growing intermixed with SSW, with Eurasian watermilfoil, forked duckweed, widgeon grass (*Ruppia cirrhosa*), muskgrass, and coontail as the species most frequently observed with SSW. For a detailed description of the sub-PI findings please see the November 2023 Staff Memorandum report prepared by the Commission.[205]

As of the 2024 aquatic plant survey, SSW is still primarily located in Trinke Lagoon and near the "colony area" of the main Lake. However, it was also observed in Abbey Marina in the Village of Fontana-on-Geneva and in the eastern bay of the Lake near the City of Lake Geneva (Figure 2.35).

SSW has demonstrated the capacity to thrive in a range of aquatic habitats in the Lake. In Trinke Lagoon, SSW grows from mucky, organic sediment in shallow water with low clarity and intermixed with species typically observed in more nutrient-rich waters, such as coontail, curly-leaf pondweed, and elodea. Within the main Lake, SSW has been observed in both shallow and deep high clarity waters from sediment that is a mixture of sand and marl. In this habitat, SSW has formed either monocultural beds or can grow intermixed with native species that prefer more mesotrophic conditions, such as muskgrass and widgeon grass. As SSW has been observed as deep as 98 feet in clear-water lakes within its native range, it is possible that SSW could spread to deeper waters in the Lake.[206] Consequently, it is unlikely that control efforts will eradicate the SSW population from the lake, particularly as active control efforts have not demonstrated significant success on SSW in other lakes in southeastern Wisconsin.[207] Recommended monitoring and management strategies for SSW are further discussed in Chapter 3.

[205] Starry Stonewort and Forked Duckweed Survey of Geneva Lake, Walworth County, Wisconsin. *November 30, 2023. Southeastern Wisconsin Regional Planning Commission.*
[206] *Olsen, "Danish Charophyta. Chronological, Ecological and Biological Investigation," in* Biologiske Skrifter *1–240, 1944.*

[207] *https://dnr.wisconsin.gov/topic/Invasives/fact/StarryStonewort*

Yellow Iris

While not necessarily a true aquatic organism, yellow iris (*Iris pseudacorus*) is a flowering wetland plant that is native to Eurasia. Commonly used in horticulture in the United States, it can easily spread to nearby shorelines, stream banks and into marshes. The above ground portion of the plant can grow up to five feet tall in the right condition and can grow in dense stands, outcompeting native shoreline and wetland species. When in bloom its flowers are bright yellow. However, when the plant is not in bloom it can easily be mistaken for its native cousin, the Northern Blue Flag Iris (*Iris versicolor*).[208] Yellow iris is poisonous to organisms and when it outcompetes native plants, can reduce food sources for insects and animals.[209]

In Geneva Lake, populations of yellow iris have been verified since it was first discovered in 2019. However, since the yellow takes 2-3 years to fully mature, it is likely that it was existing around Geneva Lake earlier than 2019.

Aquatic Plant Management Options

Aquatic plant management techniques can be classified into the following five groups.

- *Physical measures* – barriers, such as lake bottom coverings, are used to block sunlight and/or plant growth;
- *Biological measures* – natural agents, such as herbivorous insects, are used to impede undesirable plant growth;
- *Manual measures* – manipulation of plants by human beings. This can involve physical removal of plants by individuals using hand-held rakes or by hand-pulling individual plants.
- *Mechanical measures* – manipulation of plants using machines. This includes cutting (cut plants must be removed from the water), harvesting (where a machine both cuts and recovers cut plants and fragments) and suction harvesting; and,
- *Chemical measures* – introducing chemical compounds toxic to or restraining plant growth. This can include the use of aquatic herbicides to kill nuisance and nonnative aquatic plants.

[208] *Campbell, S., P. Higman, B. Slaughter, and E. Schools. 2010. A Field Guide to Invasive Plants of Aquatic and Wetland Habitats for Michigan. Michigan DNRE, Michigan State University Extension, Michigan Natural Features Inventory. 90 pp.*

[209] *Forest Health Staff. 2006. Yellow Iris: Iris pseudacorus L. Weed of the Week. U.S. Department of Agriculture Forest Service. Newton Square, PA. Available http://na.fs.fed.us/fhp/invasive_plants/weeds/yellow-iris.pdf*

More information regarding these alternatives is provided in the following sections. All control measures are stringently regulated and most require a State of Wisconsin permit. Chemical controls, for example, require a permit and are regulated under Chapter NR 107, "Aquatic Plant Management," of the *Wisconsin Administrative Code*, while placing bottom covers (a physical measure) requires a WDNR permit under Chapter 30 of the *Wisconsin Statutes*. All other aquatic plant management practices are regulated under Chapter NR 109, "Aquatic Plants: Introduction, Manual Removal and Mechanical Control Regulations," of the *Wisconsin Administrative Code*.[210]

The aquatic plant management elements described below consider alternative management measures consistent with the provisions of Chapters NR 103, "Water Quality Standards for Wetlands," NR 107, and NR 109 of the *Wisconsin Administrative Code*. Furthermore, the alternative aquatic plant management measures are consistent with the requirements of Chapter NR 7, "Recreational Boating Facilities Program," and with the public recreational boating access requirements relating to eligibility under the State cost-share grant programs set forth in Chapter NR 1, "Natural Resources Board Policies," of the *Wisconsin Administrative Code*.

Physical Measures

Lake bottom covers and light screens control rooted plants by creating a physical barrier that reduces or eliminates plant-available sunlight. They are often used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open channels for motorboats. Various materials can be used with varied levels of success. For example, pea gravel, which is usually widely available and relatively inexpensive, is often used as a bottom cover material despite the fact that plants readily recolonize pea gravel deposited upon lake bottoms. Other options include synthetic materials such as polyethylene, polypropylene, fiberglass, and nylon. Synthetic barriers can provide relief from rooted plants for several years. However, they are susceptible to disturbance by watercraft propellers and to gas build-up from decaying plant biomass trapped under the barrier and therefore may have to be placed and removed each year. Whatever the case, the WDNR does not permit these kinds of controls. Consequently, lake-bottom covers are not a viable aquatic plant control strategy for the Lake.

[210] At the time of plan development, the WDNR is proposing revisions to NR 107 and NR 109 that would result in a merger of these rules into an updated NR 107. More information regarding aquatic plant management regulations can be found on the WDNR website at https://dnr.wisconsin.gov/topic/lakes/plants/rules.

Biological Measures

Biological controls offer an alternative approach to controlling nuisance or exotic plants. Biological control techniques traditionally use herbivorous insects that feed upon nuisance plants. This approach has been effective in some southeastern Wisconsin lakes.[211] An example of this type of control is the milfoil weevil (*Eurhychiopsis lecontei*). Milfoil weevils do best in lakes with dense Eurasian water milfoil beds where the plants reach the surface and are close to shore. Furthermore, to prosper, milfoil weevils prefer lakes with natural shoreline areas where leaf litter provides habitat for over-wintering, have little boat traffic, and which have balanced panfish populations.[212] This technique is not presently commercially available, making the use of introduced milfoil weevils a non-viable option. Additionally, since the Lake only has a small population of Eurasian water milfoil, has highly developed shore areas, and has intense boat activity, milfoil weevils are not well suited for application on most of Geneva Lake.

Manual Measures

Manual removal of specific types of vegetation provides a highly selective means of controlling nuisance aquatic plant growth, including invasive species such as Eurasian water milfoil.

Two common manual removal methods are: raking and hand-pulling. Each rely on physically removing target plants from the Lake. Removing plant material from the Lake reduces nutrient loads and the volume of materials that contribute to lake-bottom sediment accumulation, helping to incrementally maintain water depths and improve water quality. Furthermore, removing target plants reduces their reproductive potential. Raking and hand-pulling are described in more detail in the following paragraphs.

Raking is conducted in nearshore areas with specially designed hand tools. Raking allows nonnative plants to be removed in shallow nearshore areas and also provides a safe and convenient method to control aquatic plants in deeper nearshore waters around piers and docks. The advantages associated with using rakes include: 1) the tools are relatively inexpensive ($100 to $150 each), 2) they are easy to use, 3) they

[211] B. Moorman, A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control, Lake Line, Vol. 17, No. 3, pp. 20-21, 34-37, September 1997; see also, C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy, Insect Influences in the Regulation of Plant Population and Communities, pp. 659-696, 1984; and C.B. Huffacker and R.L. Rabb, editors, Ecological Entomology, John Wiley, New York, New York, USA.

[212] Panfish such as bluegill and pumpkinseed are predators of herbivorous insects. High populations of panfish lead to excess predation of milfoil weevils.

generate immediate results, and 4) they immediately remove plant material from a lake (including seeds and plant fragment) thereby reducing nutrient release and sedimentation from decomposing plant material and reducing the reproductive potential of target plants. Should Geneva Lake residents decide to implement this method of control, an interested party could acquire a number of these specially designed rakes for riparian owners to use on a trial basis.).

If lake users are satisfied with rakes, additional property owners should be encouraged to purchase and use rakes. In areas where other management efforts are not feasible, raking is a viable option to manage overly abundant or undesirable plant growth.

The second manual control method - hand-pulling whole plants (stems, roots, leaves, and seeds) where they occur in isolated stands - provides an alternative means of controlling plants such as Eurasian water milfoil and curly-leaf pondweed. This method is particularly helpful when attempting to target nonnative plants in the high growth season when native and nonnative species often coexist and intermix. This method is more highly selective than rakes, mechanical removal, and chemical treatments, and if carefully applied, is less damaging to native plants. Additionally, physically removing plant materials prevents sedimentation and nutrient release from targeted plants, which incrementally helps maintain water depth and better water quality. Physical removal also reduces the amount of target plant seed and plant fragments, which helps reduce the reproductive ability of the target plants. Volunteers or homeowners could employ this method, as long as they are properly trained to identify Eurasian water milfoil, curly-leaf pondweed, or any other invasive plant species of interest. WDNR provides a wealth of guidance materials, including an instructional video describing manual plant removal, to help educate volunteers and homeowners.

Pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, aquatic plants may be raked or hand-pulled without a WDNR permit under the following conditions:

- Eurasian water milfoil, curly-leaf pondweed, and purple loosestrife may be removed if the native plant community is not harmed in the process.
- No more than 30 lineal feet of shoreline may be cleared, and this total must include shoreline lengths occupied by docks, piers, boatlifts, rafts, and areas undergoing other plant control treatment. In general, regulators allow vegetation to be removed up to 100 feet out from the shoreline.
- Plant material that drifts onto the shoreline must be removed.

- The shoreline is not a designated sensitive area.
- Raked and hand-pulled plant material must be removed from the lake.

Any other manual removal program requires a State permit, unless specifically used to control designated nonnative invasive species such as Eurasian water milfoil. In general, State manual aquatic plant removal permits call for all hand-pulled material to be removed from the lake. No mechanical equipment (e.g., towing equipment such as a rake behind a motorized boat or using weed rollers) may be legally used without a WDNR-issued permit. Recommendations regarding hand-pulling and raking are included in Chapter 3.

Mechanical Measures

Two methods of mechanical harvesting are currently permitted and employed in Wisconsin. These methods include use of an aquatic plant harvester (mechanical harvesting) and suction harvesting. More details about each are presented below.

<u>Plant Harvesting</u>

Aquatic plants can be mechanically gathered using specialized equipment known as harvesters. This equipment consists of an adjustable cutting apparatus that cut plants at selected depths from the surface to up to about five feet below the water surface and a collection system (e.g., a conveyor and a basket) that gathers most cut plant material. Mechanical harvesting can be a practical and efficient means of controlling sedimentation and plant growth, as it removes plant biomass which would otherwise decompose and release nutrients and sediment into a lake. Mechanical harvesting is particularly effective for large-scale projects.

An advantage of mechanical harvesting is that the harvester, when properly operated, "mows" the tops of aquatic plants, thus typically leaving enough living plant material in the lake to provide shelter for aquatic wildlife and to stabilize lake-bottom sediment. None of the other aquatic plant management methods leave living plant material in place after treatment**.** Aquatic plant harvesting also has been shown to facilitate growth of suppressed native aquatic plants by allowing light to penetrate to the lakebed. This is particularly effective when controlling invasive plant species that commonly grow very early in the season when native plants have not yet emerged or appreciably grown. Finally, harvesting does not kill native plants in the way that other control methods do. Instead, this method simply trims them back.

A disadvantage of mechanical harvesting is that the harvesting process may fragment plants and, thereby, unintentionally facilitate the spread of Eurasian water milfoil and starry stonewort, both of which utilize fragmentation as a means of propagation, particularly in areas where plant roots have been removed. This further emphasizes the need to prevent harvesting that removes the roots of native plants. Harvesting may also agitate bottom sediments in shallow areas, thereby increasing turbidity and resulting in deleterious effects such as smothering of fish breeding habitat and nesting sites. Agitating bottom sediment also increases the risk of nonnative species recolonization, as invasive species tend to thrive on disrupted and/or bare lake bottom. To this end, most WDNR-issued permits do not allow deep-cut harvesting in water less than three feet deep, [213] which limits the utility of this alternative in many littoral areas. Nevertheless, if employed correctly and carefully under suitable conditions, harvesting can benefit navigation lane maintenance and can ultimately reduce regrowth of nuisance plants while maintaining native plant communities.

Some cut plant fragments can escape the harvester's collection system. This negative side effect is fairly common. To compensate for this, most harvesting programs include a plant pickup program. The plant pickup program uses the harvester to gather and collect significant accumulations of floating plant debris and includes regular pickup from the docks of lakefront property owners who actively rake plant debris onto their docks.[214] This kind of program, when applied systematically, can reduce plant propagation from plant fragments and can help alleviate the negative aesthetic consequences of plant debris accumulating on shorelines. However, it is important to note that plant fragments from normal boating activity (particularly during weekends) create far more plant fragments than generated from the harvesting operations.

[213]*Deep-cut harvesting is harvesting to a distance of only one foot from the lake bottom. This is not allowed in shallow areas because it is challenging to properly ensure that the harvester does not hit the lake bottom in these areas.*

[214]*The plant pick-up program could also collect plant materials generated by landowner raking and/or hand-pulling along their own shoreline.*

Suction Harvesting (DASH)

An alternative aquatic plant harvesting method has emerged called Diver Assisted Suction Harvesting (DASH). First permitted in 2014, DASH (also known as suction harvesting) is a mechanical process where divers identify and pull select aquatic plants by their roots from the lakebed and then insert the entire plant into a suction hose that transports the plant to the lake surface for collection and disposal. The process is essentially a more efficient and wide-ranging method for hand-pulling aquatic plants. Such labor-intensive work by skilled professional divers is, at present, a costly undertaking and long-term evaluations will be needed to evaluate the efficacy of the technique. Nevertheless, many apparent advantages are associated with this method, including: 1) lower potential to release plant fragments when compared to mechanical harvesting, raking, and hand-pulling, thereby reducing spread and regrowth of invasive plants like Eurasian water milfoil; 2) increased selectivity in terms of plant removal when compared to mechanical and hand harvesting, thereby reducing the loss of native plants; and 3) lower potential for disturbing fish habitat. However, DASH can provide relief of nuisance native and nonnative plants around piers. If individual property owners choose to employ DASH, an NR 109 permit is required.

Both mechanical harvesting and suction harvesting are regulated by WDNR and require a permit. Non-compliance with permit requirements is legally enforceable and may lead to fines and/or complete permit revocation. The information and recommendations provided in this report will help frame permit requirements. Permits can be granted to cover up to a five-year period.[215] At the end of that period, a new plant management plan must be developed. The updated plan must consider the results of a new aquatic plant survey and must evaluate the success or failure and effects of completed plant management activities.[216] These plans and plan execution are overseen by the WDNR aquatic invasive species coordinator for the region.[217]

[215]Five-year permits are granted so that a consistent aquatic plant management plan can be implemented over that time. This process allows the aquatic plant management measures that are undertaken to be evaluated at the end of the permit cycle.

[216]Aquatic plant harvesters must submit reports documenting harvesting activities as an integral part of permit requirements.

[217]Information on the current aquatic invasive species coordinator can be found on the WDNR website.

Chemical Measures

Aquatic chemical herbicide use is stringently regulated. A WDNR permit and direct WDNR staff oversight is required during application. Chemical herbicide treatment is used for short time periods to temporarily control excessive nuisance aquatic plant growth. Chemicals are applied to growing plants in either liquid or granular form. Advantages of chemical herbicides aquatic plant growth control include low cost as well as the ease, speed, and convenience of application. However, many drawbacks are also associated with chemical herbicide aquatic plant control including the following examples.

- **Unknown and/or conflicting evidence about the effects of long-term chemical exposure on fish, fish food sources, and humans.** The U.S. Environmental Protection Agency, the agency responsible for approving aquatic plant treatment chemicals, studies aquatic plant herbicides to evaluate short-term exposure (acute) effects on human and wildlife health. Some studies also examine long-term (chronic) effects of chemical exposure on animals (e.g., the effects of being exposed to these herbicides for many years). However, it is often impossible to conclusively state that no long-term effects exist due to the animal testing protocol, time constraints, and other factors. Furthermore, long-term studies cannot address all potentially affected species.[218] For example, conflicting studies/opinions exist regarding the role of the chemical 2,4-D as a human carcinogen.[219] Some lake property owners judge the risk of using chemicals as being excessive despite legality of use. Consequently, the concerns of lakefront owners should be considered whenever chemical treatments are proposed. Moreover, if chemicals are used, they should be applied as early in the season as practical. This helps assure that the applied chemical decomposes before swimming, water skiing, and other active body-contact lake uses begin.[220] Early season application also is generally the best time to treat EWM and curly-leaf pondweed for a variety of technical reasons explained in more detail as part of the "loss of native aquatic plants and related reduction or loss of desirable aquatic organisms" bullet below.

[218]U.S. Environmental Protection Agency, EPA-738-F-05-002, 2,4-D RED Facts, June 2005.

[219]M.A. Ibrahim et al., "Weight of the Evidence on the Human Carcinogenicity of 2,4-D", Environmental Health Perspectives 96: 213-222, December 1991.

[220]Though the manufacturers indicate that swimming in 2,4-D-treated lakes is allowable after 24 hours, it is possible that some swimmers may want more of a wait time to lessen chemical exposure. Consequently, allowing extra wait time is recommended to help lake residents and l users can feel comfortable that they are not being unduly exposed to aquatic plant control chemicals.

- **Reduced water clarity and increased risk of algal blooms.** Water-borne nutrients promote growth of both aquatic plants and algae. If rooted aquatic plant populations are depressed, demand for dissolved nutrients will be lessened. In such cases, algae tend to become more abundant, a situation reducing water clarity. For this reason, lake managers must avoid needlessly eradicating native plants and excessive chemical use. Lake managers must strive to maintain balance between rooted aquatic plants and algae - when the population of one declines, the other may increase in abundance to nuisance levels. In addition to upsetting the nutrient balance between rooted aquatic plants and algae, dead chemically treated aquatic plants decompose and contribute nutrients to lake water, a condition that may exacerbate water clarity concerns and algal blooms.
- **Reduced dissolved oxygen/oxygen depletion.** When chemicals are used to control large mats of aquatic plants, the dead plant material settles to the bottom of a lake and decomposes. Plant decomposition uses oxygen dissolved in lake water, the same oxygen that supports fish and many other vital beneficial lake functions. In severe cases, decomposition processes can deplete oxygen concentrations to a point where desirable biological conditions are no longer supported.[221] Ice covered lakes, and the deep portions of stratified lakes, are particularly vulnerable to oxygen depletion. Excessive oxygen loss can inhibit a lake's ability to support certain fish and can trigger processes that release phosphorus from bottom sediment, further enriching lake nutrient levels. These concerns emphasize the need to limit chemical control and apply chemicals in *early* spring, when EWM and curly-leaf pondweed have not yet formed dense mats.
- **Increased organic sediment deposition.** Dead aquatic plants settle to a lake's bottom, and, because of limited oxygen and/or rapid accumulation, may not fully decompose. Accumulation of this material can create flocculent organic-rich sediment and ultimately reduce water depth. Care should be taken to avoid creating conditions leading to rapid thick accumulations of dead aquatic plants to promote more complete decomposition of dead plant material.
- **Loss of native aquatic plants and related reduction or loss of desirable aquatic organisms.** EWM and other invasive plants often grow in complexly intermingled beds. Additionally, EWM is physically similar to, and hybridizes with, native milfoil species. Native plants, such as pondweeds, provide food and spawning habitat for fish and other wildlife. A robust and diverse native plant community forms the foundation of a healthy lake, and the conditions needed to provide and host desirable gamefish.

[221] *The WDNR's water quality standard to support healthy fish communities is 5 mg/L for warmwater fish communities and 7 mg/L for coldwater fish communities.*

Fish, and the organisms fish eat, require aquatic plants for food, shelter, and oxygen. If native plants are lost due to insensitive herbicide application, fish and wildlife populations often suffer. For this reason, if chemical herbicides are applied to the Lake, these chemicals must target EWM or curly-leaf pondweed and therefore should be applied in early spring when native plants have not yet emerged. Early spring application has the additional advantage of being more effective due to colder water temperatures, a condition enhancing herbicidal effects and reducing the dosing needed for effective treatment. Early spring treatment also reduces human exposure concerns (e.g., swimming is not particularly popular in early spring).

- **Need for repeated treatments.** Chemical herbicides are not a one-time silver-bullet solution – instead, treatments need to be regularly repeated to maintain effectiveness. Treated plants are not actively removed from the Lake, a situation increasing the potential for viable seeds/fragments to remain after treatment, allowing target species resurgence in subsequent years. Additionally, leaving large expanses of lakebed devoid of plants (both native and invasive) creates a disturbed area without an established plant community. EWM thrives in disturbed areas. In summary, applying chemical herbicides to large areas can provide opportunities for exotic species reinfestation and new colonization which in turn necessitates repeated and potentially expanded herbicide applications.
- **Hybrid watermilfoil's resistance to chemical treatment**. The presence of hybrid watermilfoil complicates chemical treatment programs. Research suggests that certain hybrid strains may be more tolerant to commonly utilized aquatic herbicides such as 2,4-D and Endothall.[222,223] Consequently, further research regarding hybrid watermilfoil treatment efficacy is required to apply appropriate herbicide doses. This increases the time needed to acquire permits and increases application program costs.
- **Effectiveness of small-scale chemical treatments**. Small-scale EWM treatments using 2,4-D have yielded highly variable results. A study completed in 2015 concluded that less than half of 98 treatment areas were effective or had more than a 50 percent EWM reduction.[224] For a treatment to be effective, a target herbicide concentration must be maintained for a prescribed exposure time. However, wind, wave, and other mixing actions can dissipate herbicide doses, which decrease their

[222] *L.M. Glomski and M.D. Netherland, "Response of Eurasian and Hybrid Watermilfoil to Low Use Rates and Extended Exposures of 2,4-D and Triclpyr," Journal of Aquatic Plant Management 48: 12-14, 2010.*

[223] *E.A. LaRue et al., "Hybrid Watermilfoil Lineages are More Invasive and Less Sensitive to a Commonly Used Herbicide than Their Exotic Parent (Eurasian Watermilfoil)," Evolutionary Applications 6: 462-471, 2013.*

[224] *M. Nault et al., "Control of Invasive Aquatic Plants on a Small Scale," Lakeline 35-39, 2015.*

effectiveness in the target area and negatively impact non-target areas and species. Therefore, when deciding to implement small-scale chemical treatments, the variability in results and treatment cost of treatment should be examined and contrasted.

Other Measures

An unconventional tactic that can also be used is the "hands-off" approach, where no active management strategies are used such as harvesting or chemical application. The logic behind this approach is that, given time, the lakes will pull themselves back into ecological equilibrium after the introduction of a nonnative species. While this does not mean the nonnative population will cease to exist, it is thought that the populations will decrease to a size that allows the waterbody to recover and maintain balance.

Researchers with the WDNR recognized the need for long-term data on EWM populations and have subsequently been collecting lakeside aquatic plant data on 12 unmanaged lakes across the state. These lakes all had populations of EWM and have conducted little to no management of the EWM during the study years. WDNR researchers found that of the 12 study lakes, 8 have seen EWM populations declining over the study period, which indicates that this "hands-off" management strategy can be a viable approach.[225]

Past and Current Aquatic Plant Management

On Geneva Lake, little to no whole lake aquatic plant management has been conducted. It is common, however, for individual riparian property owners to apply for limited permits to mechanically remove or chemically treat aquatic plants surrounding their piers and boat lifts. Nonetheless, the majority of permits are for chemical treatment and mechanical harvesting remains only a small portion of the aquatic plant management. Some groups such as homeowner associations (HOA) will coordinate their aquatic plant management but only for the riparian area where the HOA resides. One example of this is the Trinke Estates who have chemically treated the Trinke Estates Lagoon since 2018.[226]

After SSW was discovered in the Lake GLEA attempted to utilize diver-assisted hand pulling to remove SSW in the main lake in 2021. However, this was not deemed effective due to findings of SSW at the same spot the following year. Thus, efforts at using diver-assisted hand pulling were not attempted again. The WDNR

[225] *Eurasian watermilfoil: long-term trends in unmanaged populations. WDNR AIS Research Projects. EGAD # 3200-2021-15. December 2021.*

[226] *Trinke Estates HOA 2018 chemical application permit # SE-2018-65-0313.*

permit application site shows records of aquatic plant management permits dating back to 2012.[227] However, it is likely that riparian property owners may have been conducting small scale management for prior to 2012, but there are no records to substantiate this.

2.7 FISHERIES AND AQUATIC ANIMALS

Healthy fish, bird, amphibian, reptile, and mammal populations require good water quality, sufficient water level/flow volumes, healthy aquatic and terrestrial plant populations and species mixes, access to life-cycle critical habitat, and well preserved or maintained aquatic and terrestrial habitat. Wildlife populations can be maintained or even enhanced by implementing best management practice. Since water supply maintenance, water quality enhancement and aquatic plant management (all of which help maintain or enhance wildlife populations) have been discussed previously in this chapter, this section focuses on issues that help maintain and expand habitat, allow key management decisions to be made, and using BMPs and targeted strategies to enhance aquatic and terrestrial wildlife populations.

Zooplankton and Rotifers

Zooplankton are microscopic animals which inhabit the same environment as phytoplankton, the microscopic plants that constitute their primary food source. They serve as stepping stone between primary producers such as algae and phytoplankton and upper trophic levels such as macroinvertebrates and fishes. Due to their ability to move themselves through water, zooplankton typically occupy a much broader vertical distribution in the water column than do the more sessile phytoplankton. While generally microscopic, some lake-dwelling zooplankton are visible to the naked eye. Common zooplankton in freshwater lakes include cladocerans, copepods, protozoans, and rotifers. A healthy zooplankton population can reduce lake algal abundance, improve water clarity, and support populations of planktivorous fish. Like phytoplankton, zooplankton and rotifer populations have been sampled nearly every year since 1997. Over 30 species of zooplankton and over 50 species of rotifers have been documented over the years (see Tables 2.14 and 2.15).[228]

[227] *https://permits.dnr.wi.gov/water/SitePages/Permit%20Search.aspx*

[228] *Data collected and provided by GLEA.*

Invasive Aquatic Animals

The terms "nonnative" and "invasive" are often confused and incorrectly assumed to be synonymous. Nonnative is an overarching term used to label living organisms introduced to new areas beyond their native range with intentional or unintentional human help. Nonnative species may not necessarily harm ecological function or human use values in their new environments. Invasive species, on the other hand, are the subset of nonnative species that have damaging impacts on the ecological health of their new environments and/ or are considered a nuisance to human use values. In summary, invasive species are non-native but not all non-native species are invasive.

Introducing invasive species, either plants or animals, can severely disrupt both terrestrial and aquatic natural systems. Since invasive species often have no natural predators to control their growth, they are often able to reproduce prolifically and outcompete native species for space and other necessary resources. This can have devastating effects on native species that have well developed interdependencies with other native plants and animals.

Zebra Mussels and Quagga Mussels

Originally introduced to the Great Lakes in the 1980s via commercial cargo ships' ballast water, Zebra mussels (*Dreissena polymorpha*) are small mollusks not native to North America. Due to their invasive species status, zebra mussels are a restricted species in Wisconsin.[229] Since their initial introduction to the Midwest, it is thought that recreational activities have been the main cause of their spread to inland lakes in Wisconsin. Zebra mussels can be accidentally transported in their various life stages. During their larval stage they can be spread through residual water left in boats and other recreational equipment. As adults they will attach themselves to structures including boat hulls, buoys and aquatic plants which if not carefully removed, can be unknowingly transported lake to lake. Being prolific filter feeders, zebra mussel can have large impacts on a lake's ecosystem including:

- Attaching themselves to native mussels, effectively smothering them
- Deplete food supply for fish and aquatic organisms by filter feeding out plankton and algae from the water
- Increase water clarity by depleting the waterbody of algae and plankton

[229] *For more information on Zebra mussels see: https://dnr.wisconsin.gov/topic/Invasives/fact/Zebra*

- Increase likelihood of toxic harmful algal blooms by preferentially filter feeding and avoiding consumption of blue-green algae

Zebra mussel have been documented and populations verified in Geneva Lake since 1995. Since their discovery, the GLEA has been monitoring zebra mussel populations every four years. The GLEA utilizes artificial zebra mussel substrate plates to collect population data at three sites across the Lake.[230] In 2024 during the routine zebra mussel monitoring, a new species of mussel previously not documented in the Lake was discovered: the quagga mussel (*Dreissena bugensis*). Individual mussels, suspected to be quagga mussels, were found among zebra mussels on the plate samplers. Upon further investigation, GLEA staff found larger specimens in the nearshore areas of the lake[231]. The full grown mussels indicate that quagga mussels have been in Geneva Lake for 2-3 years or potentially longer. WDNR and numerous experts on quagga mussels weighed in to confirm the identification of the quagga mussels. Unfortunately, Geneva Lake is the first inland lake in Wisconsin to have a verified population of quagga mussels. [232]

Quagga mussels are a prohibited species in the State of Wisconsin.[233] They are close relatives to zebra mussels. Like their relatives, quagga mussels are prolific filter feeders and can drastically change an aquatic ecosystem's food web.[234] Quagga mussels are larger, reaching a size of up to 4 centimeters; are more triangular; and are often less strongly striped than zebra mussels (see Figure 2.36). Unlike zebra mussels that typically prefer hard substrates, quagga mussels can colonize both hard and soft substrates, including sand and mud and have been known to survive down to depths of 130 meters.[235] Like zebra mussels, quagga mussels can clog water intake pipes which can damage power and water treatment plants. Dense populations of quagga mussels can also build up in places that can hinder the recreational use of lakes, such as piers, break walls, buoys, boats, and beaches.[236] Quagga mussels are thought to be the more

[230] *See "Zebra Mussel Survey" on the following GLEA webpage for more information regarding zebra mussel monitoring: https://www.gleawi.org/geneva-lake-data.*

[231] *Communication between GLEA staff and Commission staff. Commission staff assisted in the preliminary identification of the quagga mussels. WDNR staff and several external research experts confirmed the identification.*

[232] *Correspondence from WDNR Southeast Region Aquatic Invasive Species Biologist, Patrick Siwula.*

[233] *For more information on the Quagga Mussels see: https://dnr.wisconsin.gov/topic/Invasives/fact/QuaggaMussel*

[234] *Ibid.*

[235] *For more information on the Quagga Mussels see: https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=95*

[236] *For more information on the Quagga Mussels see: https://dnr.wisconsin.gov/topic/Invasives/fact/QuaggaMussel*

aggressive of the two *Dreissena* mussel species and have been seen to outcompete zebra mussels in the Great Lakes.[237, 238, 239]

Currently there are no viable methods of eradication for quagga or zebra mussels. Prevention of their spread is the best defense against them. Small-scale removal of the mussel from boats, docks and other equipment, while feasible, can be costly, difficult, and time consuming. Additionally, no pesticides have been approved by WDNR for use in controlling or eradicating populations of *Dreissena* mussels.

Banded Mystery Snail

Banded Mystery snails (*Viviparus georgianus*) are native to southeastern United States and are considered invasive in the Midwest. Originally purposely introduced to the Hudson River basin in the 1850s, subsequent introduction is thought to have been from aquarium trade.[240, 241] The snails are found in a variety of habitats including soft, silty substrate, rocky substrates, sand and detritus covered lake and river bottoms. The snails have been known to be omnivores, feeding on diatoms and algae as well as fish eggs in some cases leading to increased mortality of largemouth bass eggs as were found in laboratory and ponds settings.[242] Banded mystery snails were first verified to be in Geneva Lake in 2019.[243]

Rusty Crayfish

Native to the Ohio River Basin, the rusty crayfish (*Faxonius rusticus*, formally known as *Orconectes rusticus*) is found across most of the upper Midwest in both lake and stream habitats.[244] Humans can be credited

[237] *Nalepa, T.F., D.L. Fanslow, and S.A. Pothoven. 2010. Recent changes in density, biomass, recruitment, size structure, and nutritional state of Dreissena populations in southern Lake Michigan. Journal of Great Lakes Research 36:5-19*

[238] *Wilson, K.A., E.T. Howell, and D.A. Jackson. 2006. Replacement of zebra mussels by quagga mussels in the Canadian nearshore of Lake Ontario: the importance of substrate, round goby abundance, and upwelling frequency. Journal of Great Lakes Research 32:11-28.*

[239] *Nalepa, T.F., C.M. Riseng, A.K. Elgin, and G.A. Lang. Abundance and Distribution of Benthic Macroinvertebrates in the Lake Huron System: Saginaw Bay, 2006-2009, and Lake Huron, including Georgian Bay and North Channel, 2007 and 2012. NOAA Technical Memorandum GLERL-172. NOAA, Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 54 pp. (2018)*

[240] *Mills, E.L., J.H. Leach, J.T. Carlton, and C.L. Secor. 1993. Exotic species in the Great Lakes: a history of biotic crises and anthropogenic introductions. Journal of Great Lakes Research 19(1):1-54.*

[241] *Jokinen, E.H. 1992. The freshwater snails (Mollusca: Gastropoda) of New York State. New York State Museum Bulletin 482:vi -112*

[242] *Eckblad, J.W., and M.H. Shealy, Jr. 1972. Predation on largemouth bass embryos by the pond snail. Transactions of the American Fisheries Society 101(4):734-738.*

[243] *https://apps.dnr.wi.gov/lakes/invasives/AISDetail.aspx?roiseq=225751084*

[244] *https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=214*

with introduction of the rusty crayfish into Wisconsin, with angler bait bucket emptying thought to be the primary cause of introduction.[245] The rusty crayfish inhabits areas of lakes that have rocks, log, or other debris that they can use for shelter. They prefer cobble areas which give them able areas to hide, but will inhabit clay, silt, sand, and gravel bottoms.[246] Rusty crayfish can outcompete native crayfish species and, in many lakes, have almost completely replaced native species. Additionally, rusty crayfish can consume vast stands of aquatic plants, which are critical to the health of lakes. While there is no record of the year when rusty crayfish were first discovered in Geneva Lake, its populations have long since been verified and seen in the Lake. There are very few methods that can be used to reduce rusty crayfish populations. Intense harvest and removal of the crayfish can reduce populations, but true eradication of populations is not feasible. Prevention is the best form of control. Educating anglers, bait trappers and other lake users about the threats of rusty crayfish is crucial to preventing their spread.[247]

FISHERIES

Fishery management practices can be implemented by homeowners, recreationalists, and resource managers. Such activities include catch and release angling and fish habitat enhancement, both of which help improve a lake's overall fishery. To determine the most needed and effective practices, it is important to consider each of the following.

- **The population and size structure of the fish species present in a lake—**Studies that examine the species, populations, and size structure of fish in a lake help managers understand issues that may face fish populations. For example, if low numbers of juvenile fish of a certain species are found, this may suggest that this fish species is not successfully reproducing in the lake. In such a situation, if the desire is to promote a self-sustaining population of this fish species, species-specific spawning and rearing habitat may need to be made more accessible, restored, or created. Similarly, if abundant juveniles are found with few large fish, over-fishing may be a factor limiting the maturation of fish, thereby suggesting that catch and release should be promoted in the lake. This type of information can help lake managers target specific fish population enhancement efforts efficiently and effectively.

[245] *Hobbs, H.H. III, J.P. Jass, and J.V. Huner. 1989. A review of global crayfish introductions with particular emphasis on two North American species (Decapoda, Cambaridae). Crustaceana 56: 299-316*

[246] *Taylor, C.A., and M. Redmer. 1996. Dispersal of the crayfish Orconectes rusticus in Illinois, with notes on species displacement and habitat preference. Journal of Crustacean Biology 16: 547-551.*

[247] *https://dnr.wisconsin.gov/topic/Invasives/fact/RustyCrayfish*

- **Native fish species and the history of fish stocking in a lake**—To evaluate extant fish populations, it is important to know the number, size, and species of fish introduced through stocking. For example, if only large stocked fish exist in a lake, it is likely that little to no effective natural reproduction occurs which in turn means that the lake's fishery is highly dependent on fish stocking. This may suggest that enhanced or artificial spawning and rearing areas can add value to the lake's fishery

RECENT SURVEYS

Geneva Lake has had numerous fishery surveys conducted over the years, including game fish surveys and nearshore fishery surveys. Game fish were sampled in the Lake and its tributary streams in 1976-1977. That survey effort found 22 different gamefish species, including several species of panfish, trout, and bullheads (see Table 2.16). Just over a decade later, WDNR published a report in 1998 that outlined the results of electrofishing surveys conducted on the Lake between 1996 and 1998. Seining surveys of the Lake were conducted in 2004 as part of a larger study to compare current native, nongame fish populations with those that were documented in the 1970s. The 2004 survey found that there was an overall decrease in the number of native, nongame fish species since earlier surveys. WDNR published a report in 2015 that summarized the results of electrofishing and netting surveys done in spring and fall of that year, which targeted gamefish like bass, lake trout, muskellunge, northern pike, panfish, and walleye.[248] Key findings for gamefish from this report include:

- As observed historically in the Lake, the walleye (*Sander vitreus)* population is composed of a low-density of very large individuals. Growth rates were higher than statewide averages and other lakes within southeastern Wisconsin. Stocking is an essential tool for maintaining the walleye population as the spawning habitat within the Lake is limited and young fish are highly predated by largemouth bass.[249]
- The muskellunge (*Esox masquinongy*) fishery was developing and primarily composed of young fish. Growth within the Lake "outpaced statewide averages by several inches" for this species. Muskellunge are utilizing the significant forage fish base to create a population with excellent size-structure.

[248] Roffler, Luke. Krall, Josh. Merley, Sean. *Comprehensive Fisheries Survey Report of Geneva Lake – Walworth County 2015*. Wisconsin Department of Natural Resources.

[249] *The Walworth County chapter of Walleyes for Tomorrow have greatly assisted with stocking efforts.*

- The northern pike (*Esox lucius*) population has low abundance and poor size-structure, potentially because of a tapeworm that has been infesting the fish. Muskellunge are filling the top predator void left by lack of northern pike.
- Largemouth bass (*Micropterus nigricans*) abundance was high for lakes like Geneva Lake and had good size-structure. Both largemouth and smallmouth bass (*Micropterus dolomieu*) are frequently caught in bass fishing tournaments. Surveying for these species in nearshore areas may have been hampered by the Lake's high pier density.
- Abundance of panfish, such as bluegill (*Lepomis macrochirus*) and yellow perch (*Perca flavescens*), was low, but the numbers may be depressed due to surveying challenges from pier density.
- Lake trout (*Salvelinus namaycush*) abundance was high compared to similar lakes in Wisconsin and the population has a good size-structure. The lake bathymetry and high cisco (*Coregonus artedi*) density were credited with the success of the population.

The 2015 report also included recommendations for fish population monitoring and management. Those and additional recommendations will be discussed in Chapter 3 of this management plan. The WDNR also surveyed Geneva Lake's fishes in 2024; the data and subsequent report from that survey are anticipated in fall or winter 2025.[250]

<u>Nearshore Fisheries</u>

The GLEA contracted and conducted nearshore fishery surveys of Geneva Lake in 2018,[251] 2023,[252] and 2024.[253] The 2024 survey found a total of 17 native fish species using a towed DC electrofishing barge and small mesh seines. A few species of particular interest observed in these surveys include the bowfin (*Amia calva*) and longnose gar (*Lepisosteus osseus*), which were recorded for the first time since 1978; mimic shiner (*Notropis volucellus*), which WDNR has identified as an important forage fish for the Lake's fishery; western

[250] Email communication between WDNR Fishery Biologist Travis Motl and Commission Staff, Danielle Matuszak on May 5th, 2025.

[251] Correspondence to Ted Peters, former Director of GLEA from Dave Marshall, John Lyons, Tim Larson and Will Wawrzyn regarding nearshore fish sampling summer 2018.

[252] *2023 Shoreline Fish Survey Results and Implications for Geneva Lake Management*. GLEA. Prepared by: David W. Marshall. Underwater Habitat Investigations LLC.

[253] Marshall, David. Larson, Tim. Boucher, Robert. *2024 Geneva Lake Nearshore Fishery Survey and Lake Education Event.* July 2024. GLEA.

banded killifish (*Fundulus diaphonus menona*), a rare and sensitive fish species; and least darter (*Etheostoma microperca*), a WDNR-designated Special Concern species. A notable absence from these surveys was the rainbow darter (*Etheostoma caeruleum*), which is a sensitive nearshore fish species that has not been observed in the Lake since 1978.

In general, the shoreline fish diversity, total number of species, and number of sensitive species has declined from the surveys in 1978 and potentially since 2004.[254] Both the 2023 and 2024 reports cite shoreline development, pier densities and wake generate turbulence as potential causes in declines in nearshore fishery populations. Within Geneva Lake the highest numbers of nearshore fish species richness and abundance collected in 2023 were generally associated with the highest diversity, quality, and abundance of aquatic plant community nearshore areas of the Lake in 2024. However, the 2023 report acknowledged that the nearshore fishery was still relatively intact, particularly compared with other southeastern Wisconsin lakes, and had a significant diversity of species despite significant shoreline modifications.

Cisco

Geneva Lake and other large, deep lakes in the immediate vicinity are biologically unique. Many of these deep lakes naturally host or formerly hosted cisco (*Coregonus artedi*), a fish sometimes also known as lake herring. Cisco require cold water during summer months, retreating to well-oxygenated deep-water areas. These conditions only occur in deep lakes with high water quality; lakes that harbor these conditions are known as "two-story" lakes (see Figure 2.13). Unfortunately, this fish persists in only a handful of southeastern Wisconsin lakes (Fowler, North, Oconomowoc, Okauchee, and Pine Lakes in Waukesha County and Geneva Lake).[255] However, it was once widespread in deep lakes within southeastern Wisconsin, and was also formerly found in Lac La Belle, Nagawicka, Upper and Lower Nashotah, Upper Nemahbin, Golden, and Dutchman Lakes in Waukesha County as well as Big Cedar Lake in Washington County.[256] Volunteers and WDNR are conducting surveys to determine if cisco populations still occur in Lake Beulah in Walworth

[254] *Underwater Habitat Investigations, 2023,* op. cit.

[255] *J. Lyons, J. Kampa, T. Parks, and G. Sass,* The Whitefishes of Wisconsin's Inland Lakes: The 2011-2014 Wisconsin Department of Natural Resources Cisco and Lake Whitefish Survey*, Fisheries and Aquatic Research Section, Wisconsin Department of Natural Resources, February 2015.*

[256] *A.R. Cahn, "An Ecological Study of Southern Wisconsin Fishes*," Illinois Biological Monographs *11(1), 1927.*

County, as recent previous surveys have been unable to observe this species even though it used to inhabit the lake and WDNR still maintains fishing regulations for cisco on the lake.[257,258]

The WDNR classifies Geneva Lake as a two-story lake and the Lake still hosts cisco, which was most recently observed in WDNR surveys in 2013 and 2015.[259,260] These surveys indicated that the cisco population is dense and largely comprised of smaller, younger fish. A 2015 acoustic survey indicated that Geneva Lake has one of the highest density cisco populations in Wisconsin and gill-netting catch rates were four times higher than Big Green Lake in Green Lake County.[261] As a high-fat forage fish that schools in open water, cisco are an important component of the winter fishery and fill an ecological niche that enhances the Lake's forage fish base. This generally benefits popular fish-eating gamefish, particularly lake trout and walleye.[262] In a 2015 report, WDNR fishery biologists identified the cisco population as the "driving force behind the above average gamefish growth rates" on Geneva Lake.[263] Consequently, protecting this species by sustaining the cold, well-oxygenated deep waters that it requires are an essential component to preserving the high-quality fishery experience on Geneva Lake.

FISH STOCKING AND REGULATIONS

The WDNR manages fisheries on lakes by regulating fish stocking and bag limits. According to WDNR records, public and private fish stocking has occurred on Geneva Lake since 1957 and likely occurred prior to these recorded events (see Table 2.17). Since 1957 over 17 million fishes have been stocked into Geneva

[257] *See "Cisco" section on Protect Lake Beulah webpage: https://protectlakebeulah.org/fishing, accessed June 2025.*

[258] *See the following link for Lake Beulah fishing regulations: https://apps.dnr.wi.gov/fisheriesmanagement/Public/LakeRegulation/Details?WBIC=766600&WBIC_NAME=Lake%20Beulah.*

[259] *NR 102.06(2)(i) defines a "stratified two-story fishery lake" as a "stratified lake which has supposed a cold water fishery in its lower depths within the last 50 years."*

[260] *WDNR, 2015,* op. cit.

[261] *Ibid.*

[262] *Rypel, Andrew L., Timothy D. Simonson, Dniel L. Oele, Joanna D.T. Griffin, Timothy P. Parks, David Seibel, Craig M. Rovers, Scott Toshner, Lori S. Tate, and John Lyons,* Flexible Classification of Wisconsin Lakes for Improved Fisheries Conservation and Management, *Fisheries, Volume 44, Issue 5, May 2019.*

[263] *WDNR, 2015,* op. cit.

Lake, with walleye as most stocked fish species.[264] The species stocked into Geneva Lake has primarily consisted of:

- Brown Trout (*Salmo trutta*)
- Lake Trout (*Salvelinus namaycush*)
- Muskellunge (*Esox masquinongy*)
- Northern Pike (*Esox lucius*)
- Rainbow Trout (*Salmo gairdneri*)
- Smallmouth Bass (*Micropterus dodomieu*)
- Splake (*Salvelinus fontinalis x Salvelinus namaycush*)
- Walleye (*Sander vitreus*)

The fishery regulations for each lake are set to help achieve management goals for game fish populations.[265] Fishery biologists change the regulations on a lake in responses to changes in the goals, fish population, or the waterbody itself. On Geneva Lake, the current fishery regulations indicate that the goals for game fish are as follows (see Table 2.18 for complete list of fishery regulations and management goals):[266]

Largemouth Bass and Smallmouth Bass

- Regulation: The minimum length limit is 14" and the daily bag limit is 5
- Goal: Sustain/increase densities; maintain current conditions

Muskellunge

- Regulation: The minimum length limit is 50" and the daily bag limit is 1
- Goal: Maintain/increase densities of moderate/large adults; improve reproduction; increase predation beyond current condition; increase survival/density of large/old individuals; maximize predation on smaller fishes

Northern Pike

- Regulation: No minimum length limit and the daily bag limit is 5

[264] *As mentioned earlier in this chapter, the Walworth County chapter of Walleyes for Tomorrow have been an essential partner to WDNR in stocking walleye and maintain their population within Geneva Lake.*

[265] *For more information, see the WDNR Fishery Management Regulation Toolbox at https://dnr.wisconsin.gov/sites/default/files/topic/Fishing/RegsToolboxWebFeb22.pdf.*

[266] *The WDNR fishery regulations for Geneva Lake can be found at the following link: https://apps.dnr.wi.gov/fisheriesmanagement/Public/LakeRegulation/Details?WBIC=758300.*

- Goal: Utilize self-sustained, high-density, slow-growing populations; maximize yield; reduce predation/competition

Walleye

- Regulation: The minimum length limit is 18" and the daily bag limit is 3
- Goal: Maintain/increase density of moderate/large adults; improve reproduction; increase predation beyond current conditions

Lake Trout

- Regulation: The minimum length limit is 17" and the daily bag limit is 2
- Goal: Maintain/increase density of moderate/large adults; improve reproduction; increase predation beyond current conditions

Brook, Brown, and Rainbow Trout

- Regulation: The minimum length limit is 8" and the daily bag limit is 3
- Goal: Maintain/increase density of moderate/large adults; improve reproduction; increase predation beyond current conditions

2.8 RECREATIONAL USE

Geneva Lake is located within about a one hour drive from much of the metropolitan Milwaukee area, the northern suburban communities of the Chicago metropolitan area, and from the Madison urban area. The Lake has long been a premiere destination for lake recreation in Wisconsin due to its size, depth, excellent water clarity, and proximity close to several large cities. Aesthetic viewing, angling, paddling, recreational boating, sailing, and swimming are popular recreational uses of the Lake as indicated by the 2023 lake user survey. The Lake supports multiple outdoor recreation businesses, including marinas, yacht clubs, fishing guide services, and outdoor equipment apparel stores, hotels and resorts, and restaurants.[267]

Public Beaches and Launches

Geneva Lake is a hub of recreation activity, especially during the open water months of summer. The Lake boasts numerous boat launches and beaches that are open to the public. In addition, the Lake is also surrounded by many private boat launches and marinas. The public beaches and launches are:

- Beaches
    - City of Lake Geneva Public Beach

[267] *See Visit Geneva for more information at https://www.visitlakegeneva.com/places-to-stay/*

- Hillside Road Beach
- Williams Bay Public Beach
- Linn Pier Road Beach
- Big Foot Beach State Park Swim Area
- Village of Fontana Public Beach

- Boat Launches
  - Geneva Lake -- Hillside Road Access (Town of Linn)
  - Geneva Lake -- Linn Road Access (Town of Linn)
  - Geneva Lake -- Chapin Road Carry-In Access (Town of Linn)
  - Geneva Lake -- Wrigley Drive Access (City of Lake Geneva)
  - Geneva Lake -- Lake Street Access (Fontana Municipal Launch)
  - Geneva Lake -- Williams Bay Access (Village of Williams Bay)

The Lake watershed also contains numerous other park and open space sites that allow many types of recreational use. These sites are presented in Table 2.6 and Map 2.17.

Recreational Business and Organizations

In addition to the numerous boat launches that allow for trailering and carrying in watercraft onto the Lake, the Lake is also home to numerous boat rental services and watercraft businesses (see Table 2.19). The Lake's renowned fishery provides a foundation for several bait shops and fishing guide services. Numerous businesses in the Lake watershed rely on the high-quality waters of the Lake for their success, including restaurants, hotels, resorts, museums, shops, and other venues.

Fishing

As discussed in Section 2.7, Geneva Lake hosts a robust and popular fishery with multiple gamefish species, including panfish, bass, walleye, northern pike, lake trout, and muskellunge. The gamefish species are supported through stocking efforts by the WDNR and the Walworth Chapter of Walleyes for Tomorrow as well as by a dense population of cisco, a forage fish that is a preferred prey item for several gamefish species. In the 2023 Lake user survey, approximately 43 percent of respondents indicated that they fished on the Lake while six percent participated in ice fishing. Most respondents who participated in fishing rated their experiences, including number, size, and type of fish caught, as either "Good" or "Fair" with bass, panfish, and walleye as the most popular target species. Less than two percent of respondents indicated that their fishing experience and the health of the lake fishery were "Poor." The highest numbers of fishing boats observed during the active boat surveys (discussed later in this Section) were on weekend mornings with up to forty fishing boats observed at one time.

In a spring 2025 magazine, WDNR fisheries biologists recommended Geneva Lake as one of the top family-friendly fishing waterbodies in the southeastern part of the state.[268] In recent years, the Lake has hosted at least one fishing tournament each month between May and October with most WDNR-approved tournaments focusing on largemouth and smallmouth bass.[269] As stated above, several fishing guide services and bait shops are supported by fishing on the Lake along with other nearby waterbodies, such as Lake Como and Delavan Lake.

Lake Shore Path

The Geneva Lake Shore Path is one of the Lake's most well-known and popular features with both local residents and visitors. This nearly 26-mile Path allows public walking access around the entire Lake shoreline. Approximately 92 percent of respondents in the 2023 lake user survey indicated that they used the Shore Path and the Path is highlighted in Lake tourism information.[270] Originally formed by the Potawatomi, early European settlers to the Lake preserved the Path by ensuring that land within twenty feet of the Lake shoreline was in the public domain.[271] Since that time, the Path has been maintained by riparian residents with support from several organizations, including the GLA who provides funding for Path maintenance and has codified rules regarding its usage.[272]

Lake Shoreline

The shoreline of Geneva lake has been developed for over 150 years, with wealthy Chicago, Illinois residents flocking to the area after the Chicago Fire in 1871. Since that early development, the vast majority of the

[268] *https://widnr.widen.net/s/6qcl9twhwr/wifishreportmagazinepress2025*

[269] *Fishing tournaments are regulated by the WDNR. Information regarding tournaments, including a calendar of approved events, can be found at the following link: https://apps.dnr.wi.gov/fisheriesmanagement/Tournaments/Calendar/.*

[270] *https://www.visitlakegeneva.com/things-to-do/shore-path/*

[271] *Ibid.*

[272] *Geneva Lake Association, "GLA Reviews Shore Path Rules; Signage,"* Geneva Lake Guardian, *2017*.

Lake's shoreline has been developed with residences and business ranging from summer cottages to large lake estates. While no comprehensive shoreline survey has been conducted on the lake, to quantify shoreline development and subsequent shoreline health, views from the lake path and aerial photography provide evidence of high shoreline development and usage. Many riparian properties along the lake use some form of shoreline armoring including seawalls or rip rap to attempt to mitigate erosion. The Lake's shoreline is home to numerous boathouses, houses, large swathes of manicured lawn leading directly into the lake, as well as high pier densities.

Commission staff utilized July 2023 aerial photography to count the number of piers situated on Geneva Lake's shoreline. Counts yielded 855 piers across the lake, for an average of 41 piers per mile or one pier for every 130 feet of shoreline. This is up from the estimated density of 37 piers/mile on the Lake that the WDNR estimated in 2004.[273] The 2024 Geneva Lake Boat Count of Boats Docked and Moored, conducted in August 2024 indicated that there were 991 piers on the Lake's shoreline for a density of 47 piers per mile, which represents a 27 percent increase in the number of piers compared to year 2004. While the State of Wisconsin does not have any laws prohibiting the number of piers that you can place on a property, in many cases, local ordinances will dictate the rules surrounding the size and number of piers allowed on the property. Additionally, longer piers on the Lake range an estimated 170 feet – 254 feet in length from the shoreline (see Figure 2.37), with the majority of the piers being close to the 200 foot mark in length. Some of the larger piers on the Lake can house up to 46 boats on a single pier.

High pier densities can reduce the available habitat for fishes that utilize the nearshore area. Shading caused by piers can reduce the light availability and thus limit aquatic plant growth.[274] As mentioned in the aquatic plants section, aquatic plants serve as crucial habitat for fishes and invertebrates, with many of the invertebrates and smaller nearshore fishes serving as food sources for larger game fishes. The 2023 Nearshore Fisheries Report from the GLEA noted the density of piers was significantly negatively correlated

[273] 2023 Shoreline Fish Survey Results and Implications for Geneva Lake Management. Prepared by David W. Marshall Underwater Habitat Investigations LLC. July 16th, 2023.

[274] Garrision, Paul, Marshall, David, Stremick-Thomson, Laura, Cicero, Patricia, Dearlove, Paul. "Effects of Pier Shading on Littoral Zone Habitat and Communities in Lakes Ripley and Rock, Jefferson County, Wisconsin" WDNR, Jefferson County Land and Water Conservation Department, Lake Ripley Management District. March 2005. PUB-SS-1009 2005.

(R^2 of 0.71) with fish species richness. [275] Therefore, as the density of piers increased on the shoreline, less species of fish were found in these nearshore areas. This is likely having a detrimental effect on the overall fishery of the lake since these nearshore areas are vital for the overall recruitment (i.e., spawning, nursery or rearing areas, and/or foraging) of both nongame and gamefishes in the Lake.

Historical Wisconsin Boating survey

In 1989-1990, the WDNR conducted a two-phase study of boaters that utilized Wisconsin Lakes. The first phase of the study was "Boating Pressure on Wisconsin Lakes and Rivers" with the second phase being "Boater Attitudes and Experiences".[276,277] The study was developed to fill the need for broad based information of recreational boating in the state. The information gained from the study was intended to be used to inform future law enforcement, improve boating legislation, increase boater education and safety, and future law enforcement work-load analysis. The study utilized the WDNR's boat license registry to pull at random license and address information to get the sampling pool. In addition to Wisconsin residents, the study included Wisconsin boaters who also resided in the border counties in Minnesota, Iowa, and Illinois.[278]

The study found that, statewide, Saturday and Sundays were the most popular days to boat, with 62 percent of boating done in June, July, and August. When the study looked at different regions of the state, the southeast region had very similar results for the days of the week and months that were most popular for boating. Statewide, on average the most popular type of boating activity was fishing, with over 2/3 of respondents saying they fished.[279]

[275] *2023 Shoreline Fish Survey Results and Implications for Geneva Lake Management. Prepared by David W. Marshall Underwater Habitat Investigations LLC. July 16th, 2023.*

[276] Boater Pressure on Wisconsin's Lakes and Rivers. Wisconsin Recreational Boating Study, Phase 1. Technical Bulletin No. 174. Wisconsin Department of Natural Resources. 1991.

[277] Boater Attitudes and Experiences. Wisconsin Recreational Boating Study, Phase 2. Technical Bulletin No. 180. Wisconsin Department of Natural Resources. 1992.

[278] Boater Pressure on Wisconsin's Lakes and Rivers. Wisconsin Recreational Boating Study, Phase 1. Technical Bulletin No. 174. Wisconsin Department of Natural Resources. 1991.

[279] *Ibid.*

The study noted that there was strong evidence showing increasing boat sizes and theorized that this may lead to increased conflict when it came to recreation use of surface waters. The study compared its survey responses to the national data from the United States Coast Guard. The US Coast Guard has released annual recreational boating reports for the last 65 years, with its most recent report being for the 2023 recreational year.[280] The US Coast Guard reported that in 1969 only 20 percent of registered recreational boats in the US were over 16 feet in length. That percentage jumped to 45 percent of registered recreational boats by 1989 and in 2023 just over 65 percent of registered recreational boats were over 16 feet in length.[281] The WDNR study not only noted the jump in the percentage of boats over 16 feet but also explained the jump in number of licenses for inboard motorboats. From 1986 to 1987 the number of licensed boats with inboard motors increased by four fold, with a 61 percent increase in 16-26 foot fiberglass boats.[282]

Phase 1 of the study showed that 13 percent of WI boaters chose to boat in southeastern WI, with the average boat length in 1989 being 18 feet. The average horsepower of boats used in southeastern WI was found to be 74 hp. During the summer months of June, July, and August, 47 percent of boaters fished and 44 percent of boaters said they went cruising and sailing. Only 18 percent of boaters said they water skied, and 19 percent of boaters said they swam. The boaters who frequented southeastern Wisconsin lakes said that there were moderate levels of crowding on the lakes, with 9 percent saying they were extremely crowded. Across the state, boaters said that southeastern Wisconsin lakes had the highest level of crowding on the lakes. Nearly 50 percent of southeastern Wisconsin boaters surveyed said that their boating experience in the region was “excellent or perfect”. [283]

Phase 2 of the boating study focused more on boaters’ attitudes and experiences while recreating.[284] When surveyed about what problems were considered “moderate or serious”, excessive speed (37 percent of respondents) and excessive horsepower of power boats (35 percent of respondents) were the top two

[280] *https://uscgboating.org/library/accident-statistics/Recreational-Boating-Statistics-2023-Ch2.pdf*

[281] *Ibid.*

[282] Boater Pressure on Wisconsin’s Lakes and Rivers. Wisconsin Recreational Boating Study, Phase 1. Technical Bulletin No. 174. Wisconsin Department of Natural Resources. 1991.

[283] *Ibid.*

[284] Boater Attitudes and Experiences. Wisconsin Recreational Boating Study, Phase 2. Technical Bulletin No. 180. Wisconsin Department of Natural Resources. 1992.

concerns with conflicts with personal watercraft and inconsiderate behavior of others coming close behind (see Table 2.20). The concerns described are common issues, even over 35 years later and many would argue that the severity of these issues is increasing as development and lake use in the state and southeast region also increases. When asked about crowding issues on the most frequently used waterbodies in the state, three of the top 5 waterbodies for highest perceived crowding were southeastern Wisconsin lakes. Pewaukee Lake in Waukesha County, Big Cedar Lake in Washington County, and Geneva Lake in Walworth county all had over 90 percent of respondents saying the perceived crowding levels to be “somewhat” to “extreme”. Geneva Lake had the highest percent with 95 percent respondents concerned with crowding on the Lake.[285]

Recreational Boating on Geneva Lake

Being a premiere recreational boating destination has presented challenges for the lake’s ecology and lake users. As documented earlier in this plan, the Lake now hosts several aquatic invasive species that were potentially introduced by visiting boaters. Additionally, recreational boating was identified in the 2023 and 2024 nearshore fish survey reports as having detrimental impacts to nearshore fish habitat and species.[286] In a 1989 WDNR statewide survey, Geneva Lake was reported to be the fourth most-visited inland waterbody in Wisconsin and the most-visited site in the then-WDNR Southeast District. Respondents also reported feeling the highest level of crowding on the water of any lake in Wisconsin. These results were echoed in the 2023 plan kickoff meeting, where attendees identified “boating activity” as the third-most important lake issue after water quality and invasive species, as well as in the 2023 lake user survey conducted by the Geneva Lake Conservancy where recreational boating was a common interest and concern shared amongst survey respondents. Over 75 percent of survey respondents indicated participating in “pleasure cruising” while approximately 38 percent participate in “water-skiing or tubing” and 17 percent in “wake boarding or surfing.” Many respondents also participate in non-motorized boating with 51 percent participating in “Paddling (canoe/kayak)” while 22 percent participate in “Sailing.”

As described above, Geneva Lake has multiple options to access the Lake. The Lake has four major public launches where access is limited only by the number of trailered parking spaces. In addition, the lake has several private launches, including marinas that provide valet and in-and-out services where boats are

[285] *Ibid.*

[286] *Underwater Habitat Investigations, 2023,* op. cit. and *Underwater Habitat Investigations, 2024,* op. cit.

stored in an offshore location and launched for the customer upon request. Finally, the lake has over a thousand riparian residential parcels that provide access for several thousand boats that are moored on the lake for much of the summer.

Boat Wake Impacts

"Excessive boat wakes" were tied with "other boaters not following ordinances or laws" as the most common concerns regarding the impact of boating conditions (over 70 percent of respondents) in the 2023 lake user survey. Boat wakes have been shown to have erosive effects on shorelines,[287] scour and disrupt lake bottom sediment,[288] damage aquatic vegetation, disrupt faunal communities,[289] and temporarily decrease water clarity.[290] However, boat wake energy is event-dependent and is influenced by the vessel length and weight, water depth, channel shape, and boat speed.[291] Wakes are most destructive in shallow and narrow waterways because wake energy does not have the opportunity to dissipate over distance.[292] Although boat wakes are periodic disturbances, in comparison to natural wind-generated waves, they can be a significant source of erosive wave force, due to their longer wave period and greater wave height.[293] Even small recreational vessels within 500 feet of the shoreline are capable of producing wakes that can cause shoreline erosion and increased turbidity.[294]

Shoreline conditions can also affect boat wave-induced water quality interactions within a lake. For example, armored shorelines can protect natural shoreline sediment, which can thereby prevent shoreline sediments from eroding into the lake. However, armoring potentially can increase bottom resuspension or erosion along other shoreline reaches through wave reflection/refraction. This is particularly prevalent along reaches armored with artificial materials such as concrete, masonry, or steel seawalls or steeply sloped riprap walls.

[287] *D.M. Bilkovic, J. Mitchell, E. Daviset al.,* Review of Boat Wake Wave Impacts on Shoreline Erosion and Potential Solutions for the Chesapeake Bay, *STAC Publication Number 17-002, Edgewater, MD, 2017.*

[288] *T.R. Asplund,* The Effects of Motorized Watercraft on Aquatic Ecosystems, *PUBL-SS-948-00, University of Wisconsin–Madison, Water Chemistry Program, 2000.*

[289] *T.R. Asplund, C.M. and Cook, "Effects of Motor Boats on Submerged Aquatic Macrophytes*," Lake and Reservoir Management, *13(1): 1-12, 1997.*

[290] *U. S. Army Corps of Engineers,* Cumulative Impacts of Recreational Boating on the Fox River - Chain O' Lakes Area in Lake and McHenry Counties, Illinois: Final Environmental Impact Statement, *Environmental and Social Analysis Branch, U.S. Army Corps of Engineers, Chicago, IL., 1994; T.R. Asplund,* Impacts of Motorized Watercraft on Water Quality in Wisconsin Lakes, *Wisconsin Department of Natural Resources Bureau of Research,, Madison, WI, PUBL-RS-920-96, 1996.*

[291] *STAC Publication Number 17-002, 2017,* op. cit.

[292] *Ibid.*

[293] *C. Houser, "Relative Importance of Vessel-Generated and Wind Waves to Salt Marsh Erosion in a Restricted Fetch Environment,"* Journal of Coastal Research, *262: 230-240, 2010.*

[294] *STAC Publication Number 17-002, 2017,* op. cit.

Hence, promoting natural shorelines and/or properly (i.e., gently) sloped riprap walls can help absorb wave energy as opposed to reflecting it back across the lake. Such actions in turn can improve water quality.[295] Vegetated shorelines can effectively attenuate waves in certain settings; however, there is a limit to this capacity particularly if there is frequent exposure to boat wakes.[296]

Wake sports, such as wake-boarding and wake surfing, are an issue of concern in regards to recreational use on Geneva Lake.[297] Wake boats are specifically designed to artificially enhance the height and size of boats wake to enable specific wake sports. These boats can create waves that have several times the energy and height of other powerboats, which they can achieve by using specialized equipment such as ballast tanks to increase the boat's weight as well as shaped boat hulls and hydrofoils to "shape" and heighten the boat wake.[298,299] Consequently, these boats can generate larger waves than not only other powerboats but also larger than most small inland lakes experience, except during rare high wind events.[300,301]

Since wake boats produce larger wakes than non-wake boats, their operation creates more potential for erosion on shorelines compared to other motorboats.[302] Ballast-laden wake boats are capable of producing wave heights and frequencies that may exceed those produced during the most intense summer thunderstorms and/or high winds for the majority of inland lakes in Southeastern Wisconsin.[303,304] In addition, due to the specific design of wake boats, the stern of the boats is lowered through ballast placement or mechanical means. Since the jet stream or propeller runs deeper in the water compared to

[295] *H. Harwood, "Protecting Water Quality & Resuspension Caused by Wakeboard Boats,"* LakeLine *37: 3, 2017.*
[296] *STAC Publication Number 17-002, 2017,* op. cit.
[297] *Wake boats are a type of inboard motorboat specially designed to increase wave height for specific water sports (i.e., wakeboarding and wake-surfing). To accomplish this, the hull is shaped to achieve maximum wake and many have a hydrofoil device and/or built-in ballast tanks to displace more water and create a larger wave.*
[298] *Marr, J., Riesgraf, A., Herb, W., Lueker, M., Kozarek, J., and K. Hill, A Field Study of the Maximum Wave Height, Total Wave Energy, and Maximum Wave Power Produced by Four Recreational Boats on a Freshwater Lake, University of Minnesota St. Anthony Falls Laboratory, February 2022.*

[299] *Mercier-Blais, S. and Y. Prairie, Project evaluation of the impacts of waves created by wake boats on the shores of the lakes Memphremagog and Lovering, University of Quebec, 2014*

[300] *Marr et al., 2022, op. cit.*

[301] *Water Environmental Consultants, Boat Wake Impacts Analysis: Lake Rabun and Lake Burton, Georgia, 2021.*

[302] *Smith and Jarvie, 2015,* op. cit.*; Asplund, 2000,* op. cit.
[303] *STAC Publication Number 17-002, 2017,* op. cit.
[304] *In March 2019, Sawyer County proposed a resolution/ordinance that proposes a 700-foot buffer from the shore specifically for boats creating enhanced wakes to minimize shoreline. See more information at [www.cola-wi.org/news.](www.cola-wi.org/news)*

other motorboats,[305] wake boats have a greater potential to disrupt bottom sediments.[306] Greater bottom-sediment disruption increases water turbidity and suspends phosphorus from the lake bed, decreasing water quality.[307] The deeper running propellers of wake boats also have a greater chance to uproot and or fragment aquatic vegetation, which can promote the spread of undesirable plant species and degrade the Lake's aquatic plant community.[308] Fragmentation by propellers favors invasive species, such as EWM, over native species, potentially leading to an increased spread of invasives. In addition, there also is an increased potential of introduction of new invasive species to the Lake via water pumped from wake boat ballast tanks. For example, quagga mussel (*Dreissena bugensis*) larvae, fish pathogens, or invasive plant fragments have been known to be introduced to new locations via water pumped from ship ballast tanks.

Boater Movement

The WDNR has collected survey data through the Clean Boats, Clean Waters program regarding other lakes that visiting boaters to Geneva Lake had visited up to five days before and after traveling to the Lake.[309] Visitors to the Lake had traveled to 89 other waterbodies in Wisconsin within five days before coming to Geneva Lake and they traveled to 42 other waterbodies within five days after visiting the Lake. The Lake is a significant tourist attraction, drawing visitors from across the state and including some other commonly visited lakes such as Lake Michigan, Lake Winnebago, Pewaukee Lake, Lake Mendota, Green Lake, and Minocqua Lake. However, this data also showcases the potential spread of aquatic invasive species that are present in other parts of Wisconsin. Geneva Lake undoubtedly draws visitors from other states as well, particularly Illinois, which WDNR does not maintain records of in their database. Consequently, the potential for invasive species spread to and from the lake is even higher than recognized by this database.

Lake Ordinances and Law Enforcement

Chapters 30 and 33 of the *Wisconsin Statutes* provide the authority for municipalities (or a lake district or sanitary district if authorized by the governing municipality) to enact and enforce local boating

[305]*D. Keller, "Low-Speed Boating… Managing the Wave,"* LakeLine, *37(3), 2017.*

[306] *Daeger, A., Bosch, N.S., Johnson, R., College, G., and L. Way, "Impacts on Nutrient and Sediment Resuspension by Various Watercraft Across Multiple Substrates, Depths, and Operating Speeds,"* Proceedings of the Indiana Academy of Science, *2022*.

[307]*Harwood, 2017,* op. cit.

[308]*Keller, 2017,* op. cit.

[309]*https://apps.dnr.wi.gov/boatermovement/Default.aspx*

ordinances.[310,311] Boating ordinances can include restrictions on boating speed, restrictions on types of boating activities across the entire waterbody or specified areas on the waterbody, and restrictions on types of boating activities during specified hours of the day or days of the week.[312] These ordinances are subject to advisory review by the WDNR and entities proposing to amend or repeal ordinances must provide a public notice and hold a public hearing regarding the ordinance at least 60 days before the change takes effect. For lakes where multiple municipalities have jurisdiction, such as Geneva Lake, the municipalities that cover at least 50 percent of the lake and 60 percent of the lake shoreline must pass an identical ordinance for the ordinance to be valid and enforceable for that lake.

Pursuant to *Wisconsin Statutes* Sections 30.77 and 30.81, Geneva Lake has a joint uniform lake law ordinance passed and adopted by the five municipalities with jurisdiction over the Lake that governs recreational use on the Lake.[313] A joint ordinance governing the lake was first formed in 1968 and was most recently amended and adopted in 2017. This ordinance does the following:

- Authorizes the Geneva Lake Law Enforcement Agency to enforce the ordinance
- States that the Water Safety Patrol will promote water safety on the Lake
- Adopts *Wisconsin Statutes* Section 30.50 through 30.81 regulating boating and ice traffic on public inland lakes
- Establishes speed limits and slow-no-wake hours on Geneva Lake
- Designates traffic zones and restrictions, including traffic lights
- Set regulations regarding swimming, water skiing, and spearfishing
- Prohibits littering in or polluting the Lake
- Determines the penalties for violating this ordinance or the relevant Sections of *Wisconsin Statutes*

[310] Wisconsin Statutes *Chapter 30, Navigable Waters, Harbors and Navigation. https://docs.legis.wisconsin.gov/statutes/statutes/30*

[311] Wisconsin Statutes *Chapter 33, Public Inland Waters. https://docs.legis.wisconsin.gov/statutes/statutes/33*

[312] *Wisconsin Department of Natural Resources,* A Guideline for Creating Local Boating Ordinances and Placing Waterway Markers in Wisconsin Waters, PUB-LE-317-2016, *August 2019. https://widnr.widen.net/s/lldpzrbl2s/le0317*

[313] *An Ordinance Amending Joint Uniform Lake Law Ordinance of Geneva Lake, Walworth County, Wisconsin. The Geneva Lake Law Enforcement Agency has a summary of the joint uniform lake law ordinance at the following link: https://genevalakepolice.com/resource-doc/LAKE%20ORD%20Flyer.pdf.*

As designated by the joint uniform lake law ordinance, the Geneva Lake Law Enforcement Agency, also known as the Geneva Lake Police, are authorized to enforce boating regulations on Geneva Lake.[314] As described earlier in this chapter, this inter-municipal agency was formed in 1968 and maintains a staff of 15 officers, one Sergeant, and one Commander. WDNR Conservation Wardens can also be present on Geneva Lake and can enforce state laws as well as the joint uniform lake law ordinance if that ordinance is posted at the public launch.

Moored Boat Counts

The GLEA conducts annual surveys of all boats moored, docked, or available for in-and-out service on Geneva Lake. These surveys, which typically occur in July or August, require on-the-water reconnaissance around the entire Geneva Lake shoreline as well as information requests to private marinas around the Lake to gather the in-and-out service numbers. Boats actively in use on the Lake are not included in this count. As described in the second edition of the Geneva Lake management plan, the moored boat count through 2003 averaged approximately 5,000 watercraft moored on the Lake.[315] This plan also estimated that between two and five percent of all moored boats are active on the Lake at any given time, resulting in approximately 95 and 238 active boats that are typically moored (not including boats launched on the lake).

The GLEA moored, docked, and in-and-out boat count between 2003 and 2024 is illustrated in Figure 2.38. During this period, the average number of moored, docked, and in-and-out boats was 5,196 boats with a minimum of 4,464 boats in 2017 and a maximum of 6,034 boats in 2022. A linear regression of moored boats by year indicates that the number of these boats has significantly increased throughout this period by approximately 36 boats per year (R^2 = 0.32, p-value = 0.005). Using the same two to five percent estimate as the 2008 plan, there could be between 89 and 302 boats active on Geneva that are typically moored on the lake (not including boats launched on the lake). Examples of areas with high numbers of moored boats, including the beach near Bigfoot State Park and the lakefronts near the City of Lake Geneva, Village of Fontana-on-Geneva, and the Town of Linn, are presented in Figure 2.39.

For the 2023 moored, docked, and in-and-out service boat count, the GLEA also provided a breakdown of the types of boats in the count as well as the number of in-and-out boats versus the moored and docked

[314] *https://genevalakepolice.com/*

[315] *SEWRPC CAPR No. 60, 2008,* op. cit.

boats. At 77 percent of the total boats, motorboats were the most common type followed by personal watercraft (14 percent), non-motorized vessels (five percent), and sailboats (four percent).[316] Of the 5,167 total boats, 1,604 boats were included in in-and-out service (31 percent) while the remaining 3,563 boats were moored or docked on the Lake (69 percent). Of the 1,441 in-and-out boats, 1,411 were motorboats (88 percent), 92 were non-motorized vessels (six percent), 87 were sailboats (five percent), and the remaining 14 were personal watercraft (less than one percent). For the 3,563 moored and docked boats, 2,559 were motorboats (72 percent), 701 were personal watercraft (20 percent), 162 were non-motorized vessels (four percent), and the remaining 141 were sailboats (four percent).

The 2024 GLEA tallied 5,899 total moored, docked, and in-and-out boats in a survey conducted on August 21st, 2024. At 59 percent of the total boats, motorboats were again the most common type followed by non-motorized vessels (23 percent), personal watercraft (15 percent), and sailboats (3 percent).[317] In addition to the GLEA boat count, the GLC contracted with a private drone operator to conduct a moored boat count in 2024. The operator tallied 2,860 moored boats on August 14th, 2024. These boats were not categorized by type like the GLEA count.

Active Boat Counts

With the assistance of Commission staff and a private drone operator, the GLC conducted counts of active boats on Geneva Lake in the summers of 2023 and 2024. Unlike the moored boat counts, the intent of these active boat counts is to capture the number and types of boats active on the Lake at any given time to provide a snapshot of boating activity. Due to the size of the Lake, a drone was utilized to view as much of the lake as possible at one time while conducting the count to minimize the chance of double-counting the same watercraft. The survey was conducted on seven dates in 2023 and ten dates in 2024 between June and August. These dates were selected to represent a range of boating activity conditions, including low activity on weekday mornings as well as high activity on weekend afternoons, holidays (such as July 4th), and special events like Venetian Fest. During each survey, every active boat was counted and categorized by type, such as powerboats, fishing boats, personal watercraft, and paddling boats (e.g., canoes, kayaks), and activity level, such as high speed cruising, low speed cruising, wake surfing or boating, and fishing. The survey dates and results are presented in Table 2.21.

[316] *Geneva Lake Environmental Agency,* 2023 Annual Boat Count Press Release. 456c61_131606a430da43568c17217ca8a9dd96.pdf.

[317] *Geneva Lake Environmental Agency,* Geneva Lake Boat Count of Boats Docked and Moored, *August 21, 2024.*

In 2023, the number of active boats surveyed on the Lake ranged from 29 boats on a Tuesday morning in August to 251 boats on a Saturday during Venetian Fest in August. Across all survey dates, powerboats were by far the most common boat type (572 counted boats) followed by fishing boats (120 boats), sailboats (114 boats), personal watercraft (43 boats), paddling boats (35 boats), and then all remaining watercraft, which included the mail boat (8 boats). As is common on most southeastern Wisconsin lakes, the surveys conducted on non-holiday weekdays generally had a higher proportion of fishing and sailing boats in the total boat count while weekends and holidays had a much higher proportion of powerboats in the total boat count. In addition to these boat counts, Commission staff utilized aerial imagery from July 22nd, 2023 to count 308 active boats on Geneva Lake (see Figure 2.40).

In 2024, the number of active boats ranged from 36 boats on a Monday afternoon in June to 222 boats on July 4th. As with the 2023 results, powerboats were by far the most common boat type across all surveys (775 boats), again followed by fishing boats (148 boats), and then sailboats (83 boats), personal watercraft (35 boats), paddling boats (27 boats), and all remaining watercraft (6 boats). Weekdays typically had higher proportions of fishing and sailing boats, with the exception of afternoon on Wednesday, August 14th (the start of Venetian Fest), which had the second-most powerboats of any survey date. Weekend surveys generally had much higher proportions of powerboats, although the two Friday mornings surveyed did not follow this trend.

The total number of active boats in 2023 and 2024 were similar to or lower than previous active boat surveys on Geneva Lake. These surveys also attempted to count all the boats active at one time using aerial imagery.[318] Active boat counts in the 1960s had up to 74 boats active at one time during weekday surveys and up to 184 boats active during weekend surveys.[319] Boat surveys in 1977 averaged 494 active boats with up to 650 active boats on July 4th. Boating had increased even more in a 1988 survey, which averaged 647 active boats per survey with up to 1,120 active boats on July 4th. Numbers in a 2003 survey are more similar to current active boat counts, with an average of 394 boats per survey date and up to 512 active boats on July 4th. However, it is worth noting that average boat size and horsepower have increased across the

[318] *Geneva Lake Environmental Agency,* Geneva Lake and Boating: Summary Information Sheet #6*, August 2006. For more information, see https://www.gleawi.org/_files/ugd/456c61_9967a746de66494197c64623e27a300d.pdf.*

[319] *WDNR, 1969,* op. cit.

country over the decades and consequently the impact per boat may be substantially larger in recent years, which would potentially offset the lower active boat counts.

In both the 2023 and 2024 surveys, a common boating pattern was to travel just outside the slow-no-wake buoys in a counterclockwise pattern around the Lake. This pattern is the same pattern that large tour boats take around the Lake. Counterclockwise is the preferred direction for most Wisconsin lakes with a boat travel direction set in ordinance, so this behavior is likely familiar to many boaters even though there is no set direction in the joint uniform lake law ordinance for Geneva Lake. Boaters may prefer keeping near the edges of the lake to avoid the wind, view riparian homes, and to follow in the predominant flow of traffic across the Lake. Consequently, these areas typically have a higher density of boat traffic than the open water areas in the middle of the Lake, which are more sparsely populated.

Lake Carrying Capacity

Wisconsin lakes are exceedingly popular sites for a variety of recreational uses and access to public waterways is protected through the Public Trust Doctrine. However, excessive lake use can cause ecological impacts as well as conflict between lake users, which requires lake managers to balance aesthetic, recreational, environmental, and economic goals for the lake.[320] A lake's carrying capacity refers to the amount of human use that a lake can support while still meeting expected standards, including ecological and recreational standards. Analyzing a lake's carrying capacity may include answering questions such as:[321]

- Is the water quality or aquatic biota negatively affected by excessive lake use?
- Are there enough parking spaces and facilities to support desired use?
- Can lake users safely conduct their selected recreational activities?
- Do lake users and/or residents consider the lake too crowded to use?

Commission staff analyzed whether Geneva Lake is exceeding its recommended carrying capacity in three steps: 1) counting the number and activities of active boats on the Lake, 2) determining the useable area for intensive active boating, and 3) applying published models to decide on appropriate boating densities for the Lake. Counting the active boats on the Lake was described in the previous section. To determine the

[320] *L.L. Klessig, "Load Limits for Lakes,"* Lake and Reservoir Management *10:1 69-73, 1994*.

[321] *CDM Smith,* Beaver Lake Boating Carrying Capacity Study: Literature Review, *prepared for the U.S. Army Corps of Engineers, January 2017*.

useable area for intensive boating, Commission staff calculated the acreage of the Lake that was at least 200 feet from shore and 100 feet from any pier or buoyed restricted area, as consistent with the "traffic area" described in the joint uniform lake law ordinance. This calculation resulted in approximately 4,500 acres of useable area for intensive boating activities.

Lake carrying capacity studies have attempted to quantify desirable levels of boat traffic based on meeting expected ecological and recreational standards for lakes. Many of these studies recommend an optimal boat density (i.e., acres per boat), with some studies varying the boat density depending on the boat type or activity. Recommended boat densities in published carrying capacity models have ranged from 1.3 acres per boat (for fishing boats and canoes) to 40 acres per boat (for waterskiing).[322] For this study, Commission staff applied three published models of lake carrying capacity: the 1989 Warren and Rea model, the 2001 four township model, and the 2011 Water and Land Recreation Opportunity Spectrum (WALROS) model.[323,324,325] Each of these lake carrying capacity studies provide recommended boating densities ranging from 1.3 to 20 acres per boat to cover a wide variety of boat types, recreational uses, and lake characteristics. Use rates above this threshold are considered to negatively influence public safety, environmental conditions, and the ability of a lake to host a variety of recreational pursuits.

The 2023 and 2024 recreational surveys demonstrated that highest boat use occurs during weekends and holidays. Using the most conservative estimate of boating density (2011 WALROS model) of 17 acres per boat and a useable area of 4,500 acres on the Lake, no more than 265 boats should be present on the lake at any one time to avoid use problems. The number of boats observed during active boat surveys was always lower than this optimal maximum density, with the highest number of active boats observed on August 19th, 2023 (Venetian Fest). Consequently, the documented boat use on Geneva Lake did not exceed the recommended carrying capacity for the lake during any of the active boat surveys (see Table 2.21).

[322] *CDM Smith, 2017*, op. cit.

[323] *R. Warren and P. Rea,* Management of Aquatic Recreation Resources, *Publishing Horizons, Inc., Columbus, Ohio, 1989*.

[324] *A.E. Progressive,* Four Township Recreational Carrying Capacity Study, Pine Lake, Upper Crooked Lake, Gull Lake, Sherman Lake, *Study prepared for Four Township Water Resources Council, Inc. and the Townships of Prairieville, Barry, Richland, and Ross, May 2001.*

[325] *U.S. Bureau of Reclamation,* Water and Land Recreation Opportunity Spectrum (WALROS), Users' Handbook, Second Edition, *September 2011.*

However, the 308 boats observed on June 22nd, 2023 by Commission staff using aerial imagery does exceed the recommended carrying capacity for the Lake using the WALROS model. Additionally, approximately 51 percent of respondents in the 2023 lake suer survey indicated that they either frequently change boating plans or do not boat on the lake during weekends due to excessive traffic. Management recommendations regarding boating use and pressure are provided in Chapter 3.

Recreational Boating Summary

Given its significant size and average water depth, Geneva Lake has a greater capacity than any other lake in southeastern Wisconsin to support recreational boating, including wake sports, while minimizing impacts to water quality, shoreline erosion, and disruption of lake bottom sediment and aquatic vegetation. However, balancing these recreational uses with protection of lake health may require limiting intense boating activity to deeper areas of the lake that are farther from shore. Additionally, the high numbers of visiting boats can create conflicting uses of the Lake while also exposing the lake to greater risk from invasive species. Management recommendations to help balance recreational uses while protecting its environmental quality are presented in Chapter 3.

2.9 STAKEHOLDER ENGAGEMENT

The Commission, GLC, and other partners who collaborated in developing the management plan worked to inform and engage lake stakeholders and the public through meetings, presentations, a lake user survey, and a public comment period on the plan. This section will briefly describe these efforts.

2023 Kickoff Meeting

The plan development began with a kickoff meeting in January 2023 in the City of Lake Geneva that had presentations by the Commission, GLEA, GLC, GLA, Water Alliance for Preserving Geneva Lake, Walworth County, and the WDNR. The meeting was held in the City hall and over one hundred members of the public attended to ask questions about the plan and share their concerns about the lake. The attending public could also complete a brief questionnaire to indicate their primary interests and concerns regarding Geneva Lake. This information was used to develop the 2023 lake user survey as well as a decision to host focus groups discussing the lake's water quality and recreational use, which were designated as primary concerns from many attendees.

2023 Lake User Survey Results

In 2023 the Conservancy, in partnership with the Commission, conducted the 2023 Geneva Lake User Survey to gain an understanding of who was using the Lake, how they were using it, and what some of their concerns were among other things. The survey was comprised of 41 questions broken into the following categories: Demographics, Geneva Lake Use and Perceptions, Property Management, and Geneva Lake Management (see Table 2.22 for questions and number of responses). The survey was designed to provide insight into issues regarding the lake relevant to present-day conditions, and was approved by a WDNR social scientist before being sent to residents. The GLC prepared a postcard that had a QR code and website URL that provided access to the survey, with results later tabulated and sent to SEWRPC and lake stakeholders. In total, the survey had 276 respondents, though each respondent did not necessarily answer every question. The survey was sent out to a total of 1,000 households in the surrounding area of the Lake and to 1,000 of the riparian property owners.

Respondent Profile

Over 96 percent of those who responded were over the age of 40 at the time of the survey, with only 11 respondents being under the age of 40. The Village of Williams Bay and the Village of Fontana-on-Geneva Lake were tied for having the highest number of respondents being located there, with nearly 57 percent of respondents indicating that their property is located in one of the two villages. The Town of Linn claimed 24 percent of respondents and the City of Lake Geneva just over 16 percent of respondents. The remaining 3 percent fell into the Town of Walworth, Town of Geneva or the "Other" category. Nearly 70 percent of residents who answered the survey have lived in the Geneva Lake area for over 10 years, with 1 percent (3 persons) indicating that they have lived in the area less than a year. Most respondents indicated that their property is not their year-round residence with only 40 percent indicating that they stay at their property year-round. Of those who responded to the survey, 24 percent were in the Lake's watershed, 29 percent were riparian property owners, 47 percent were persons who did not own residential property directly on the lakeshore but had access to the Lake via a shared pier. When asked how important Geneva Lake is in their choice to own property in the Geneva Lake area, 94 percent of respondents indicated that is was very important in their choice. However, 42 percent of respondents said that in their opinion, the quality of their lake experience has declined over the years and 40 percent indicated that they think the quality of their lake experience has remained the same.

Additionally, the survey asked residents to rank on a scale of 1 (most important) to 5 (least important) how important various portions of Geneva Lake were to their use and enjoyment of the Lake. Responses indicate that the north shoreline including Williams Bay is the most important area (40 percent ranked as "1"), follow by the south shoreline, the west shoreline including the Village of Fontana-on-Geneva Lake, and then the east shoreline including Geneva Bay. The middle of the Lake only had 3 respondents rank it at a 1 (most important). Besides looking at what area of the lake were often used by residents, the survey asked respondents to indicate which activities they participated in on Geneva Lake (see Q7 table and figure). The vast majority of respondents indicated that "Enjoying the view", "Walking the Lake path", and the "Tranquility" of the Lake were things they most often enjoyed about the Lake. Very few respondents indicated that "Motorized winter sports", Snorkeling or Scuba diving", or "Ice fishing" were activities they often participated in on the Lake. Boating/watercraft activities had varying levels of participation: "Pleasure Cruising" (77 percent), "Paddling (canoe/kayak)" (50 percent), "Wake boarding or surfing" (17 percent), "Water-skiing or tubing" (38 percent), and "Sailing" (22 percent).

Geneva Lake Use and Perceptions

When asked about common issues that lakes face in Southeastern Wisconsin, the main categories indicated as having a large impact on Geneva Lake were algae blooms (40 percent), invasive species (43 percent), and excessive property development (55 percent). The issues that respondents indicated have some impacts were poor water clarity (48 percent), pollutants in water (47 percent), and excessive aquatic plant growth (47 percent). However, aquatic plant grown was also the topic that received the highest percent of "no opinion" responses at 40 percent. This draws the conclusion that the majority of the concerns revolve around water quality concerns.

The frequency of which respondents said they recreated on the Lake varied based on the time of year. During the months of June through August most respondents (47 percent) indicated that they recreated on the Lake weekly with 34 percent indicated that they recreated on the Lake daily during those months. When asked the same question but for during the months of September through May, during the typical "off season", daily recreational responses dropped to only 9 percent and weekly responses dropped to 30 percent. However, the monthly recreation response increased from 1 percent to nearly 24 percent. Unsurprisingly, residents of the Lake area most often recreate on or around the Lake during the summer open water months.

When specifically asked about the frequency of going fishing during May through November, nearly half responded saying that they never went during that time. The most fished for species were Smallmouth Bass, Largemouth Bass, Panfish, and Walleye. Of those who participated in fishing, the overall enjoyment of the fishing experience ranked highly, with more than half of those with opinions indicating it was good or excellent. Piers and mooring buoys were of little interference for fishing on the Lake, as over two-thirds of fishing participants noted no obstruction. Individual aspects of the fishing experience such as fish size and health were also rated by respondents (see Q14 table and figure).

Regarding water quality, 92 percent of respondents indicated at least some level of concern about the water quality of the Lake, with 32 percent being very concerned. The survey asked respondents to specify which aspects of water quality were particular issues of concern on the Lake. Impaired fishing, swimming, and wildlife showed varying levels of concern amongst residents (see Q18 Graphs and Table). Aquatic plant growth was seen to impact recreation in small parts of the Lake for 48 percent of users, indicating specific areas of the Lake were more troublesome than others.

50 percent of Lake users reported using a motorboat on Geneva Lake at least weekly, and that most other boaters were courteous and law-abiding (69 percent). Generally, users had occasional (27 percent) to no (28 percent) impacts on their motorboat usage during summer weekdays. However, this impact increased on summer weekends and holidays, as respondents had to frequently change boating plans due to traffic (22 percent) or did not use the Lake at all during these times (29 percent). Public opinion noted adequate boat launch access (45 percent) as well as commercial pier, boat livery, and marina size and number to support enjoyment of the Lake (70 percent). Areas of friction between different recreational groups were reported to be at nearshore areas far from launches (16 percent) and public boat launches (16 percent), although 37 percent did not feel there was friction between differing groups at all. Potential boating behaviors of concern were listed in the survey, and respondents selected excessive boat wakes (70 percent), other boaters not following ordinances or laws (70 percent), and poor boating etiquette or behavior (67 percent) impacted their use and enjoyment of the Lake most severely (see Q26 graphs and table).

Property Management

When asked about property management, lake users reported applying fertilizer (41 percent), insecticide (11 percent), and herbicides (17 percent) for lawn maintenance, while over half (53 percent) used none of these options on their lawns. 60 percent of survey respondents did not own riparian property on the Lake or next to a stream. Those who were riparian owners had native plants or a vegetation buffer on their shoreline property (20 percent), or lawn grass mowed to the water's edge (9 percent) most commonly.

Survey respondents reported incorporating beneficial property management practices such as integration of native plants (63 percent), utilizing curbs and grading for diverting runoff (42 percent), and opting for gravel or a pervious pavement driveway (24 percent). Barriers for residents that impeded implementation of beneficial management practices included: "Lack of information/Unaware of practices" (35 percent), "Cost demands" (31 percent), "Physical labor demands" (25 percent), "Personal aesthetic preferences" (23 percent). Additional property information obtained showed that 73 percent of respondents did not have a septic system on their property, and those who did most frequently had their septic system pumped between 1 and 3 years (13 percent). When asked about the severity of soil erosion on their property, 58 percent of respondents indicated having no visible soil erosion, and 15 percent were unsure, suggesting a possible lack of information regarding soil erosion. In addition, when asked about awareness of available grants and programs available to implement practices that protect the Lake, 54 percent were not aware of any programs. Programs listed on the survey included the Geneva Lake Conservancy: Annual native plant sale, Geneva Lake Environmental Agency: Boat cleaning stations, Geneva Lake Conservancy: Conservation@Home, and the Wisconsin Department of Natural Resources: Healthy Lakes and Rivers. 35 percent, 29 percent, 28 percent, and 23 percent of respondents indicated awareness of the aforementioned programs, respectively. Users most frequently obtained information regarding Geneva Lake from conversations with friends and acquaintances (68 percent), and personal observations (54 percent).

Lake Management

Lake users most often reported neutral (39 percent) and positive (33 percent) attitudes regarding the current management practices of Geneva Lake. When asked to give their opinions on certain aquatic plant management practices such as chemical treatments or dredging, more residents were unsure or needed more information than those who supported or opposed certain practices. This points to a lack of information regarding the variety of aquatic plant management tools available for the Lake. Additionally, a wide variety of goals and actions for Geneva Lake were given in the survey, and residents selected up to three of the management issues that they thought would bring the most value to the Lake. The issues that received the most public support were aquatic invasive species management (54 percent), water quality monitoring (50 percent), and boating regulation enforcement (46 percent). The survey gauged lake user potential investment in lake and watershed management by asking if residents would be willing to contribute funds for this cause. 47 percent said they were unsure or needed more information, 41 percent said yes, with 12 percent said no. Potential fundraising options for lake management were given, and users were most interested in increased boat launch fees (38 percent), state and federal grant programs (25 percent), and voluntary donations from individuals (21 percent).

Geneva Lake Focus Groups

To increase stakeholder engagement and education, the GLC along with the GLEA and the Commission hosted two focus groups on May 20th and 21st of 2024. The first focus group, on May 20th, was focused on the topic of Water Quality. The second focus group on May 21st was focused on the topic of Recreation Use and Boating. Invites were sent out to stakeholders in early April 2024 with the request that they RSVP due to limited capacity at the venue (see Figure2.x GLC Focus Grp flyer 4.3.24.jpg). Eric Olsen from University of Wisconsin – Stevens Point Extension agreed to assist in moderating the focus group sessions as a non-biased voice.

The Focus Group Meetings were formed to allow stakeholders to speak on the topics and express their opinions and concerns. It was then followed by a question and answer style discussion where attendees could ask questions and discuss the topics to foster better understanding and open dialogue regarding the topics. For notes on what questions were asked and the discussions that resulted please see Appendix ***.

Public Comments Received

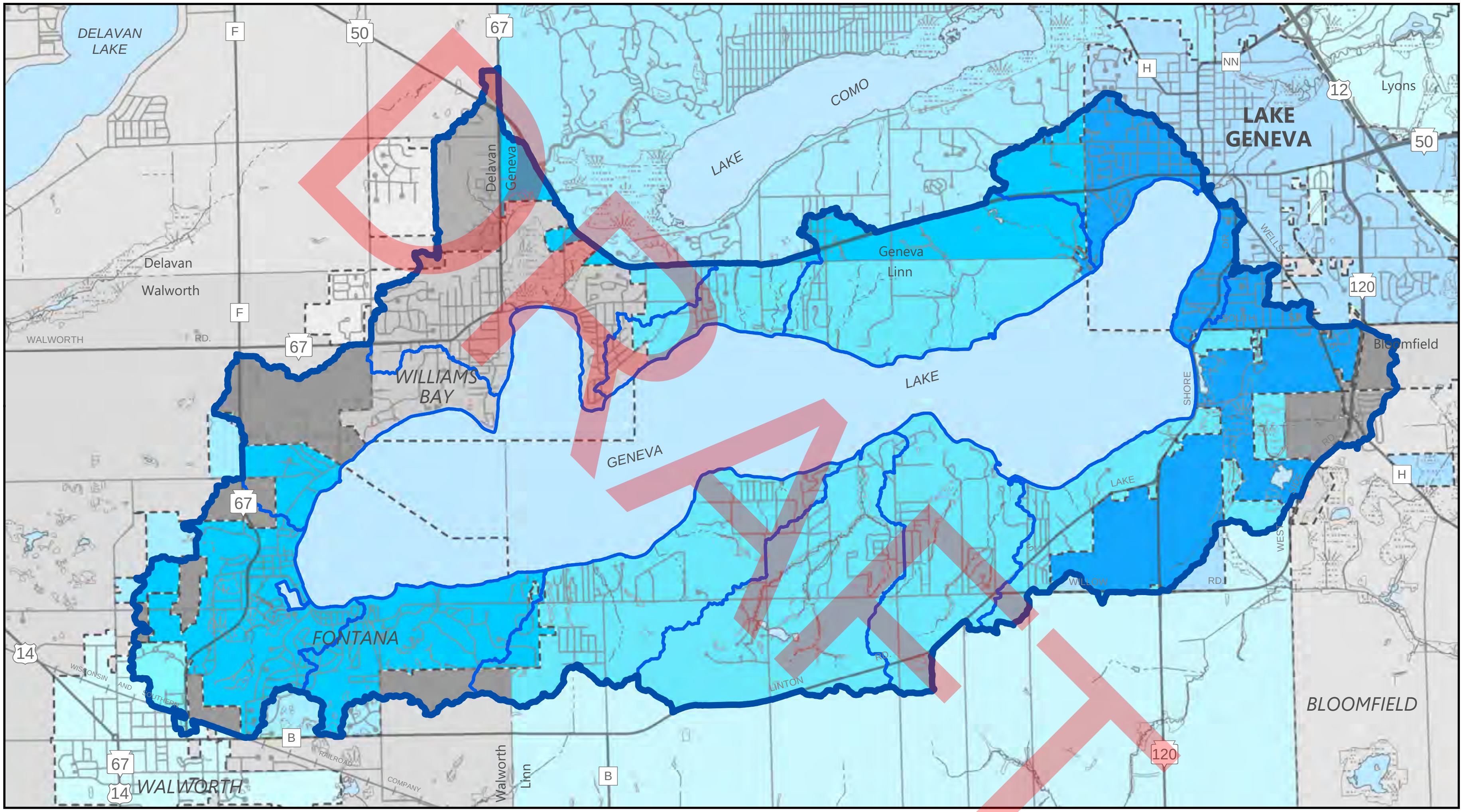
This section will be completed following the public comment period.

SEWRPC Community Assistance Planning Report Number 60 (3rd Edition)

A LAKE MANAGEMENT PLAN FOR GENEVA LAKE
WALWORTH COUNTY, WISCONSIN

Chapter 2 Maps

Map 2.1
Geneva Lake Watershed Civil Divisions: 2025



LOCAL GOVERNMENT TYPE

CITY: **UPPER CASE BOLD**

VILLAGE: *UPPER CASE ITALIC*

TOWN: Lowercase

Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

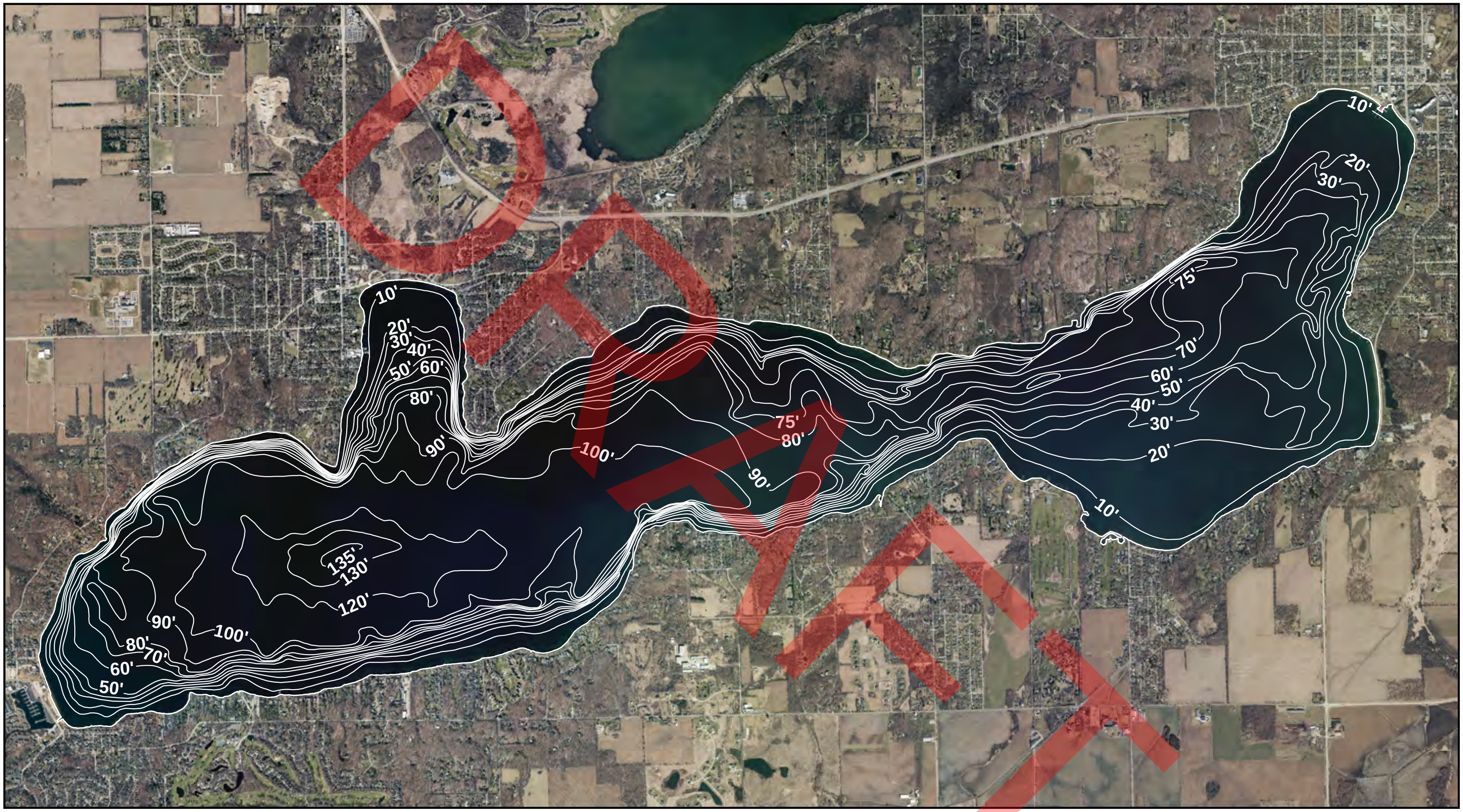
GENEVA LAKE WATERSHED
GENEVA LAKE SUBWATERSHED
SURFACE WATER

0 0.5 1 Mile

Last Updated: 02/13/2025

Source: Walworth County and Southeastern Wisconsin Regional Planning Commission

Map 2.2
Geneva Lake Bathymetry



—20'— WATER DEPTH CONTOUR IN FEET

Note: Date of Photograph 2024

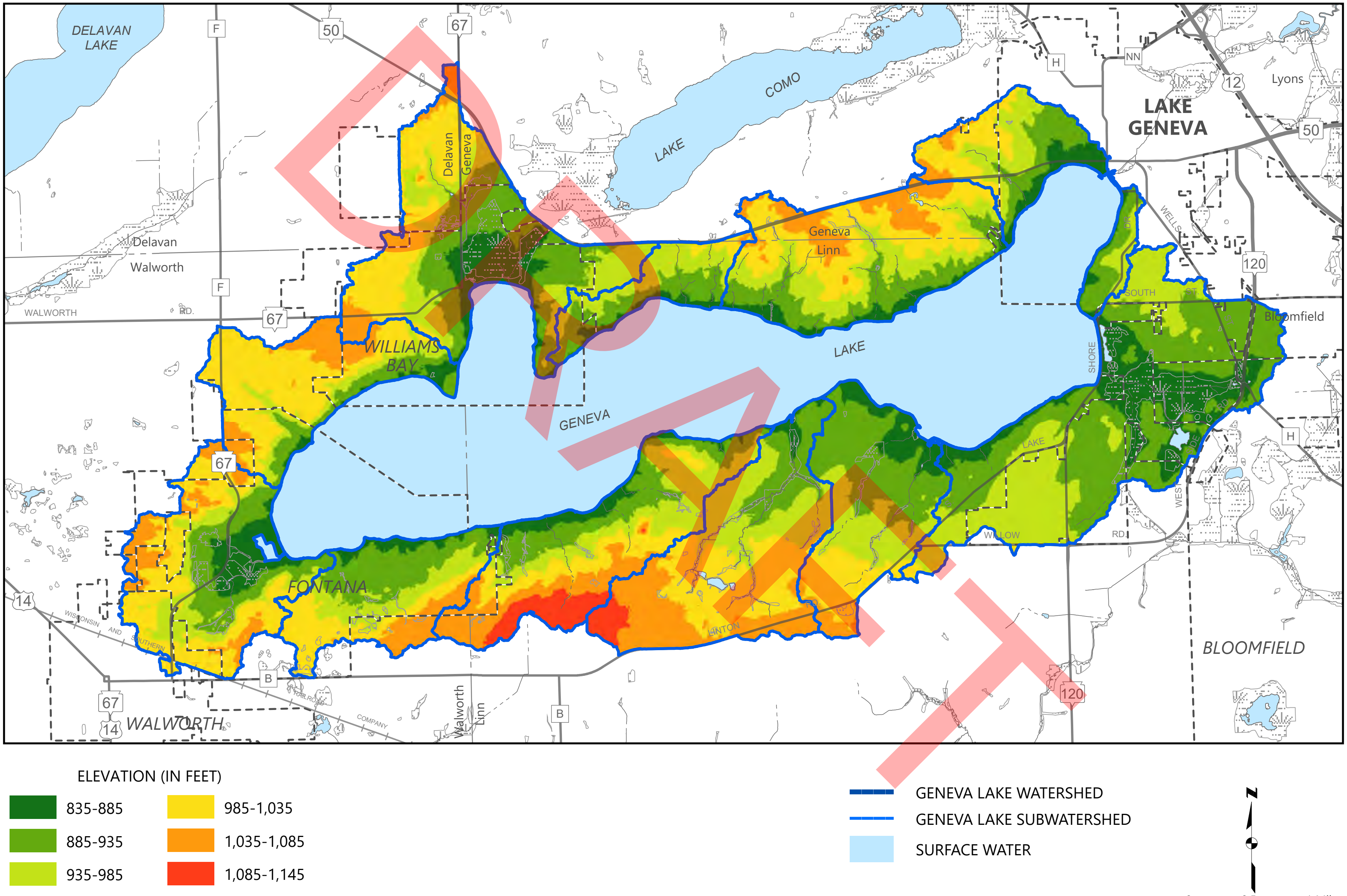
Source: Wisconsin Department of Natural Resources and Southeastern Wisconsin Regional Planning Commission

N

0 0.25 0.5 0.75 1 Mile

Last Updated: 02/12/2025

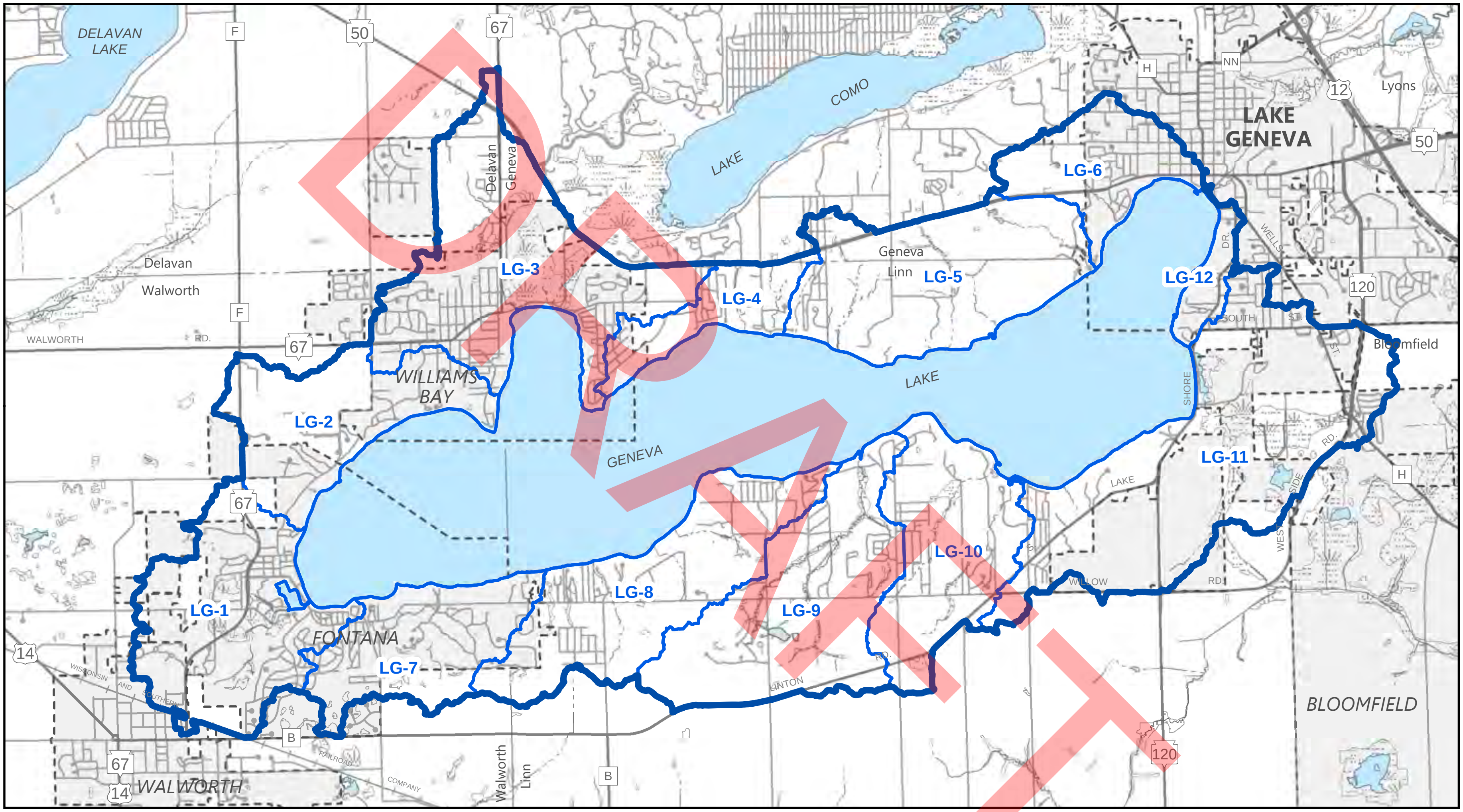
Map 2.3
Topographic Characteristics Within the Geneva Lake Watershed (2015)



Source: Walworth County and Southeastern Wisconsin Regional Planning Commission

Last Updated: 02/12/2025

Map 2.4
Surface Water Features and Subbasins Within the Geneva Lake Watershed



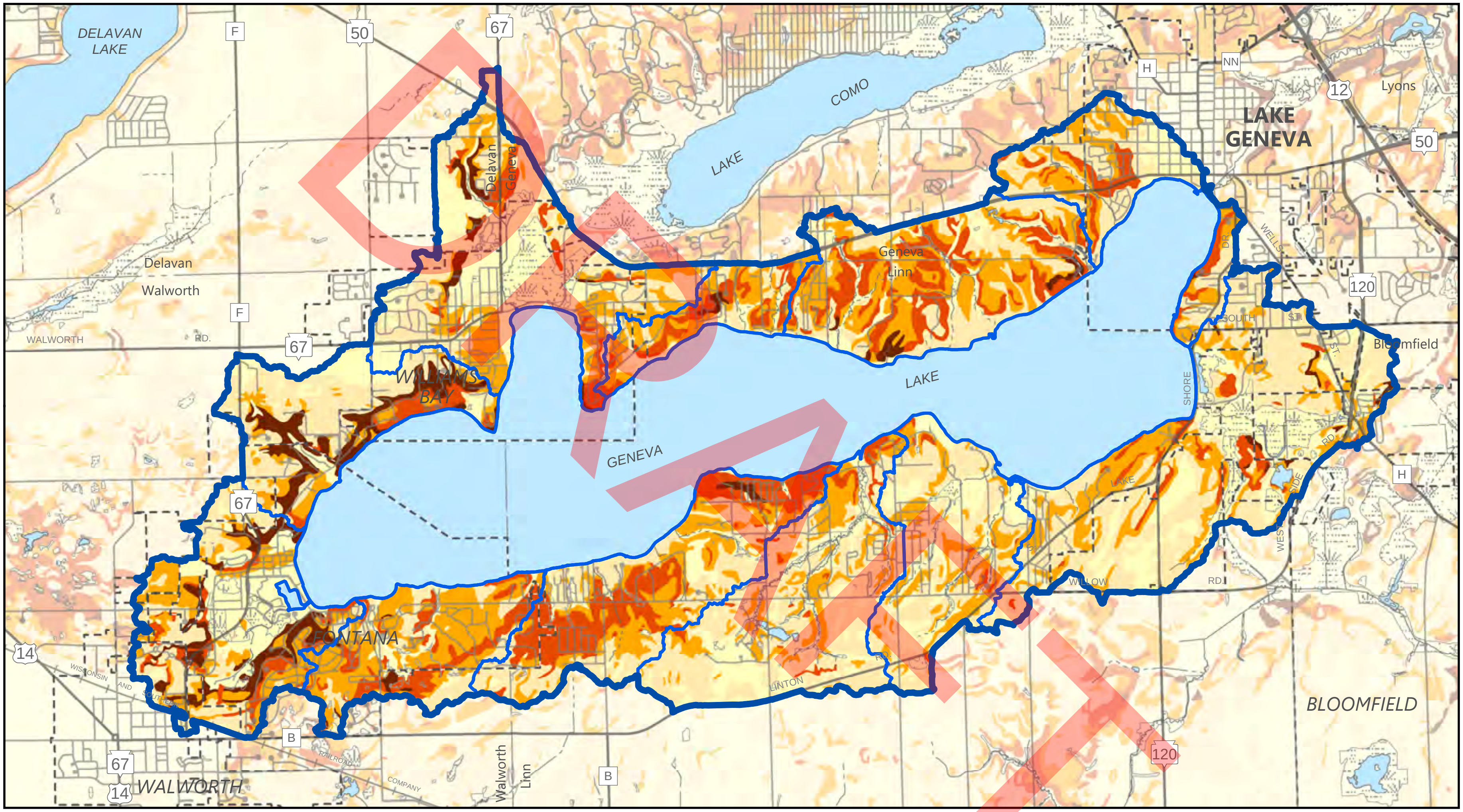
GENEVA LAKE WATERSHED
GENEVA LAKE SUBWATERSHED
SURFACE WATER

N
0 0.5 1 Mile

Last Updated: 02/12/2025

Source: Southeastern Wisconsin Regional Planning Commission

Map 2.5
Soil Slopes Within the Geneva Lake Watershed



SOILS HAVING SLOPES RANGING FROM 0 TO 2 PERCENT	SOILS HAVING SLOPES RANGING FROM 12 TO 20 PERCENT
SOILS HAVING SLOPES RANGING FROM 2 TO 6 PERCENT	SOILS HAVING SLOPES OF 20 PERCENT OR GREATER
SOILS HAVING SLOPES RANGING FROM 6 TO 12 PERCENT	

Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

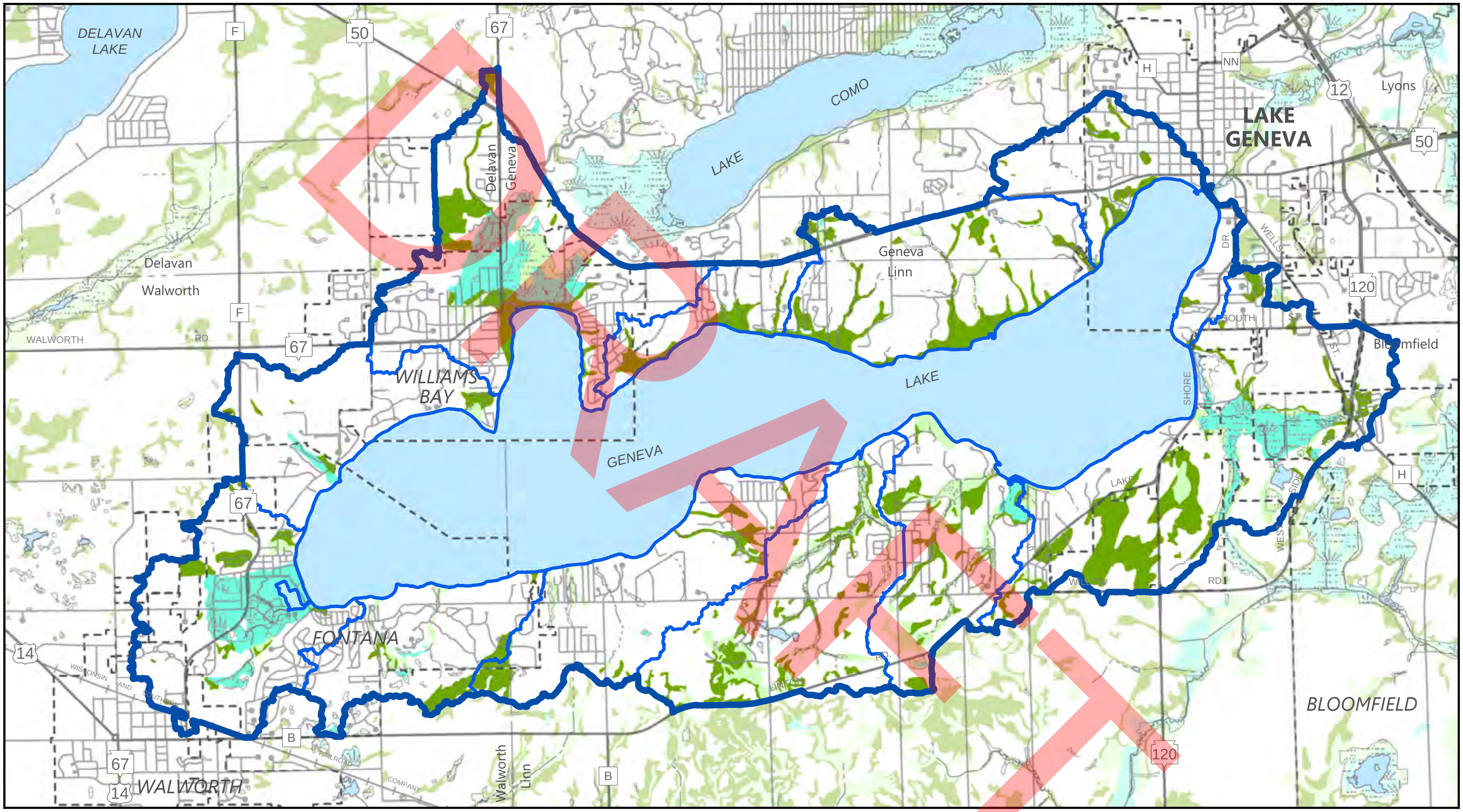
GENEVA LAKE WATERSHED
GENEVA LAKE SUBWATERSHED
SURFACE WATER

0 0.5 1 Mile

Last Updated: 02/12/2025

Source: Natural Resources Conservation Service and Southeastern Wisconsin Regional Planning Commission

Map 2.6
Hydrologic Soil Groups Within the Geneva Lake Watershed



HYDRIC SOILS

- HYDRIC
- PREDOMINANTLY HYDRIC
- PREDOMINANTLY NON-HYDRIC
- NON-HYDRIC

Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

- GENEVA LAKE WATERSHED
- GENEVA LAKE SUBWATERSHED
- SURFACE WATER

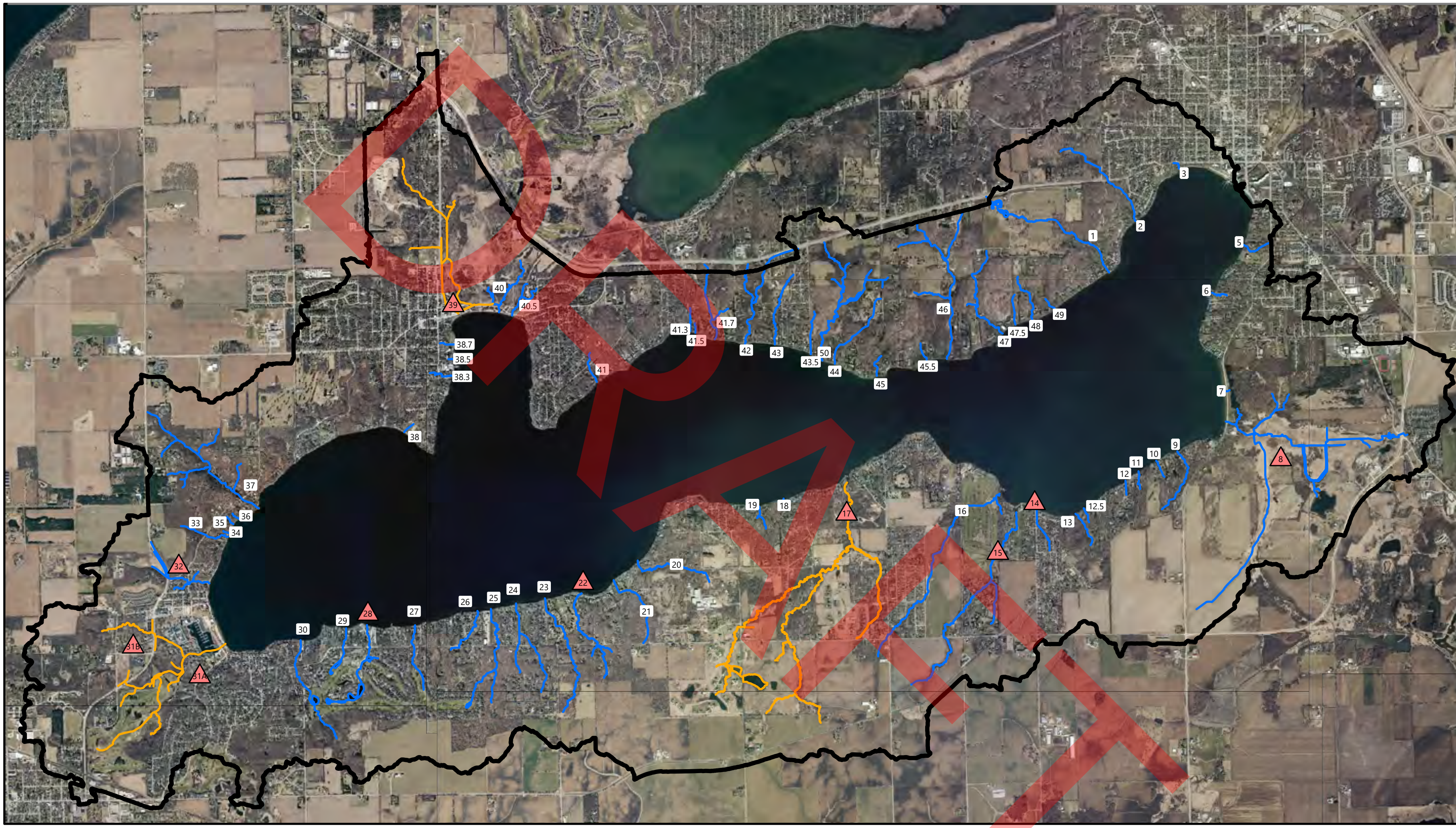
N

0 0.5 1 Mile

Last Updated: 02/12/2025

Source: Natural Resources Conservation Service and Southeastern Wisconsin Regional Planning Commission

Map 2.7
Tributaries in the Geneva Lake Watershed



NAMED TRIBUTARIES

1- Geneva Bay Estates
2- Lake Wood Drive
8- Big Foot
14-Hillside
15-Trinke
17- Birches
22- Simms
23- Shadow Lane/NWNMA
24- Chicago Club
28- Abbey Springs
31A- Potawatomi
31B- Van Slyke
32- Buena Vista
37- Gardens
39- Southwick
40- Harris
42- Elgin Club
46- Rasin

STREAM TYPE

Intermittent
Perrenial

TRIBUTARIES

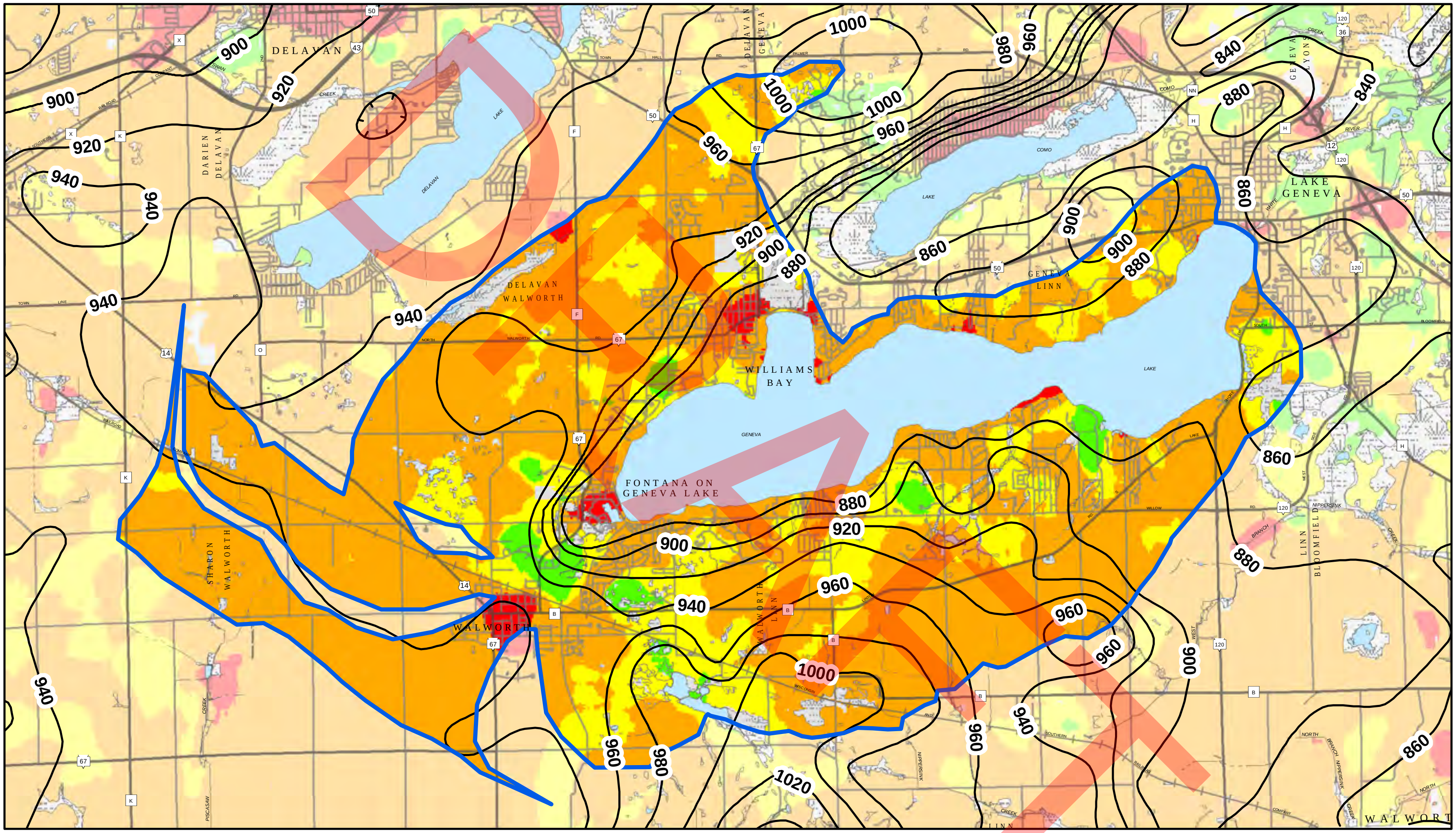
Detailed in Chapter 2.2
Not specified in Chapter

N

0 0.38 0.75 1.5 Miles

Source: SEWRPC

Map 2.8
Groundwater Elevation Contours and Recharge Potential Within and Beyond the Geneva Lake Groundwatershed



WATER RECHARGE POTENTIAL

VERY HIGH
HIGH
MODERATE
LOW
UNDETERMINED
SURFACE WATER

WATER TABLE ELEVATION CONTOUR
950 WATER TABLE ELEVATION
GENEVA LAKE GROUNDWATERSHED

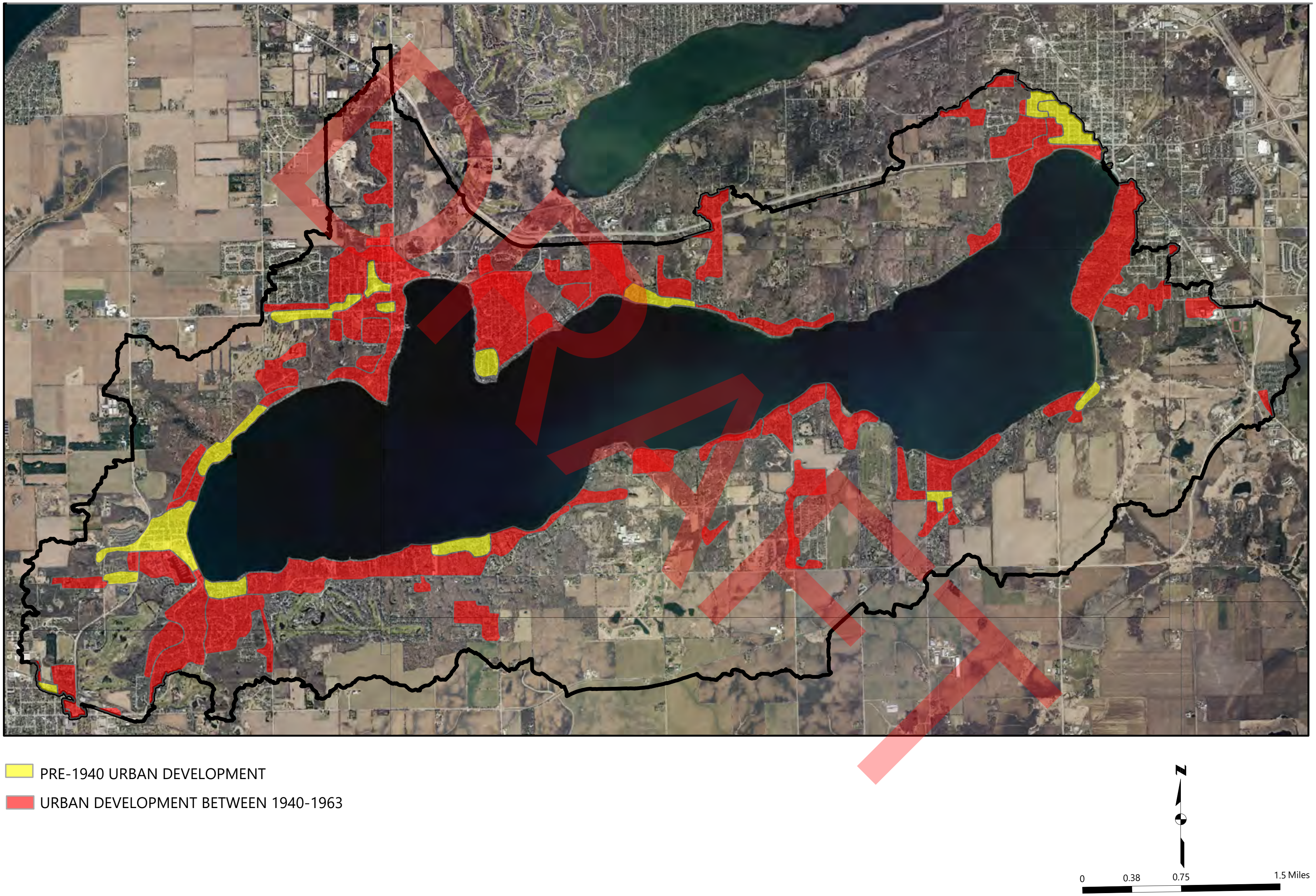
Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

The Geneva Lake groundwatershed indicates the areas contributing groundwater to Geneva Lake. This groundwatershedvis based on information from the Commission and the WGNHS.

0 0.75 1.5 2.25 3 Miles

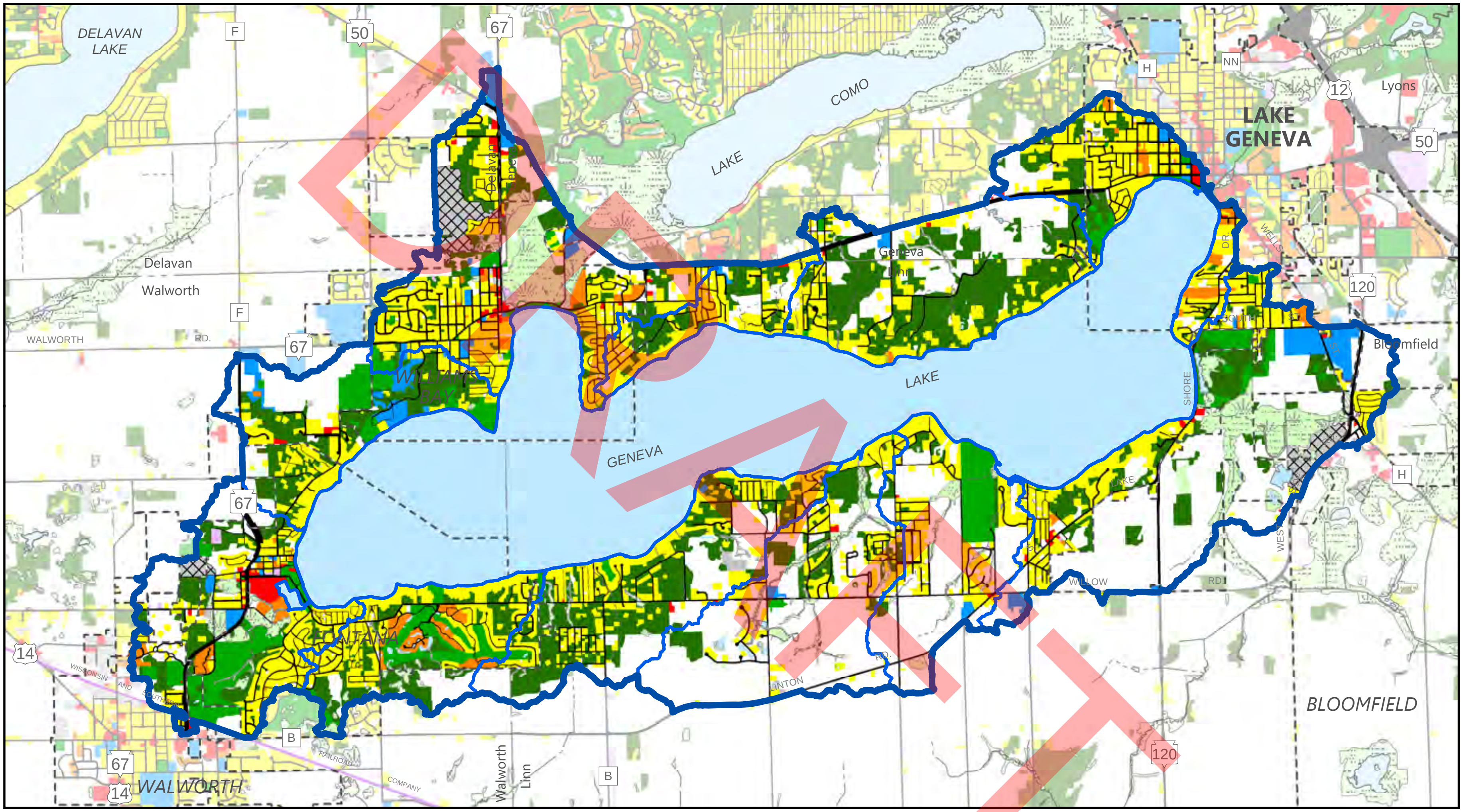
Source: Wisconsin Geological and Natural History Survey and SEWRPC

Map 2.9
Change in Urbanized Land Uses Within the Geneva Lake Watershed: 1940-1963



Source: SEWRPC

Map 2.10
Land Use Within the Geneva Lake Watershed: 2020



- SINGLE-FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL
- GOVERNMENTAL AND INSTITUTIONAL
- RECREATIONAL
- EXTRACTIVE AND LANDFILL
- STREETS AND HIGHWAYS
- RAILROAD
- OTHER TRANSPORTATION, COMMUNICATIONS AND UTILITIES
- AGRICULTURAL AND OTHER OPEN LANDS
- WETLANDS
- WOODLANDS
- SURFACE WATER

- GENEVA LAKE WATERSHED
- GENEVA LAKE SUBWATERSHED

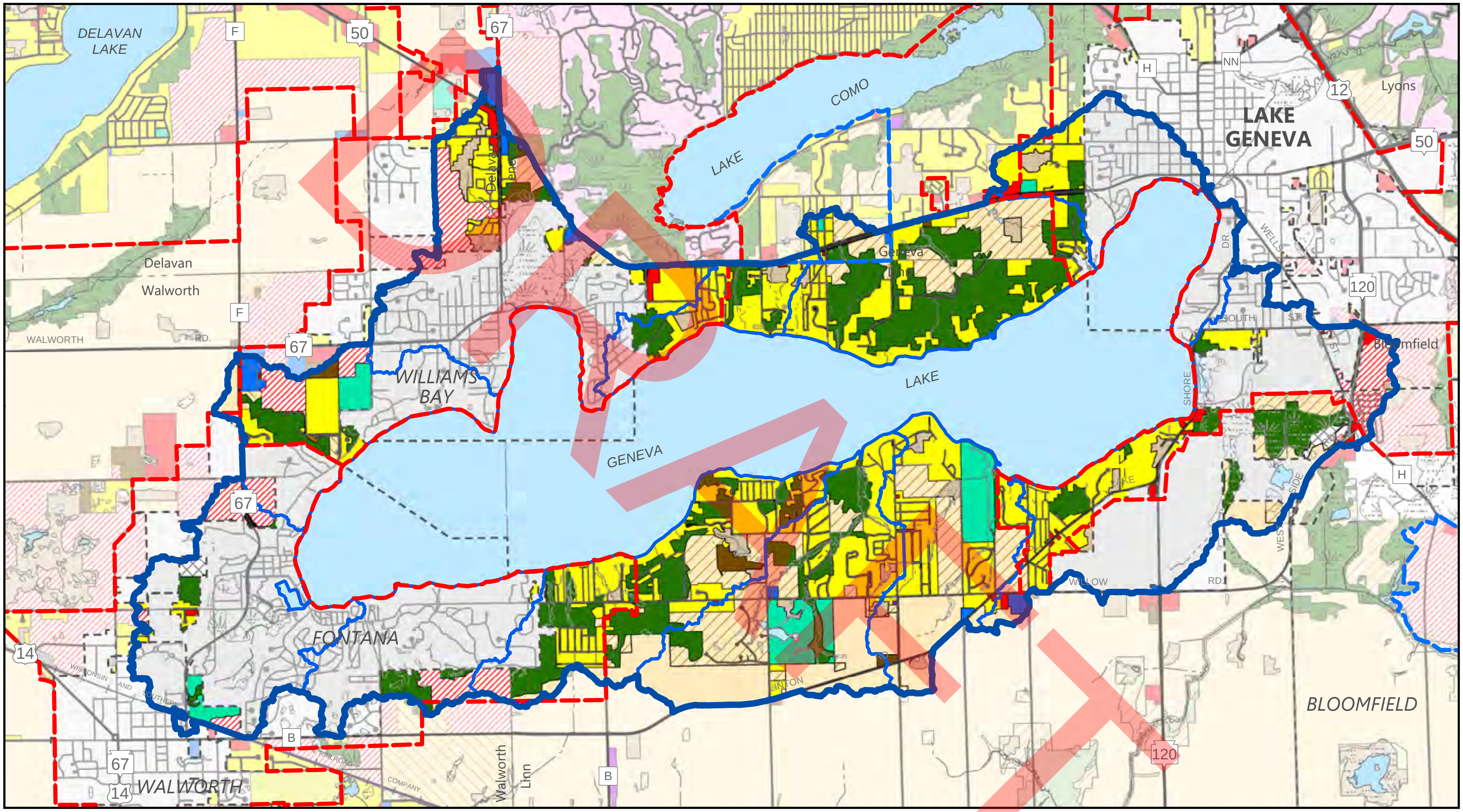
Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

0 0.5 1 Mile

Last Updated: 02/13/2025

Source: Southeastern Wisconsin Regional Planning Commission

Map 2.11
Planned Land Use Plan Within Geneva Lake Watershed: 2050



URBAN DENSITY RESIDENTIAL (LESS THAN 5.0 ACRES PER DWELLING)
RURAL DENSITY RESIDENTIAL (AT LEAST 5.0 ACRES PER DWELLING)
COMMERCIAL
COMMERCIAL/RECREATIONAL
MIXED USE
INDUSTRIAL
GOVERNMENTAL AND INSTITUTIONAL
RECREATIONAL
AGRICULTURAL RELATED MANUFACTURING, WAREHOUSING, AND MARKETING
URBAN RESERVE
STREETS AND HIGHWAYS
OTHER TRANSPORTATION, COMMUNICATION, AND UTILITIES
EXTRACTIVE
SANITARY LANDFILL
PRIME AGRICULTURAL (MINIMUM PARCEL SIZE: 35 ACRES)
OTHER AGRICULTURAL, RURAL RESIDENTIAL, AND OTHER OPEN LAND (5 TO 34 ACRES PER DWELLING)
OTHER AGRICULTURAL, RURAL RESIDENTIAL, AND OTHER OPEN LAND (5 TO 19 ACRES PER DWELLING)
OTHER AGRICULTURAL, RURAL RESIDENTIAL, AND OTHER OPEN LAND (20 TO 34 ACRES PER DWELLING)
PRIMARY ENVIRONMENTAL CORRIDOR
SECONDARY ENVIRONMENTAL CORRIDOR
ISOLATED NATURAL RESOURCE AREA
DNR/DOT LAND OUTSIDE ENNVIRONMENTAL CORRIDORS
OTHER OPEN LAND TO BE PRESERVED
SURFACE WATER
INCORPORATED AREAS
PLANNED SEWER SERVICE AREA
TOWN PROPOSED ADDITION TO SEWER SERVICE AREA
GENEVA LAKE WATERSHED
GENEVA LAKE SUBWATERSHED

Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

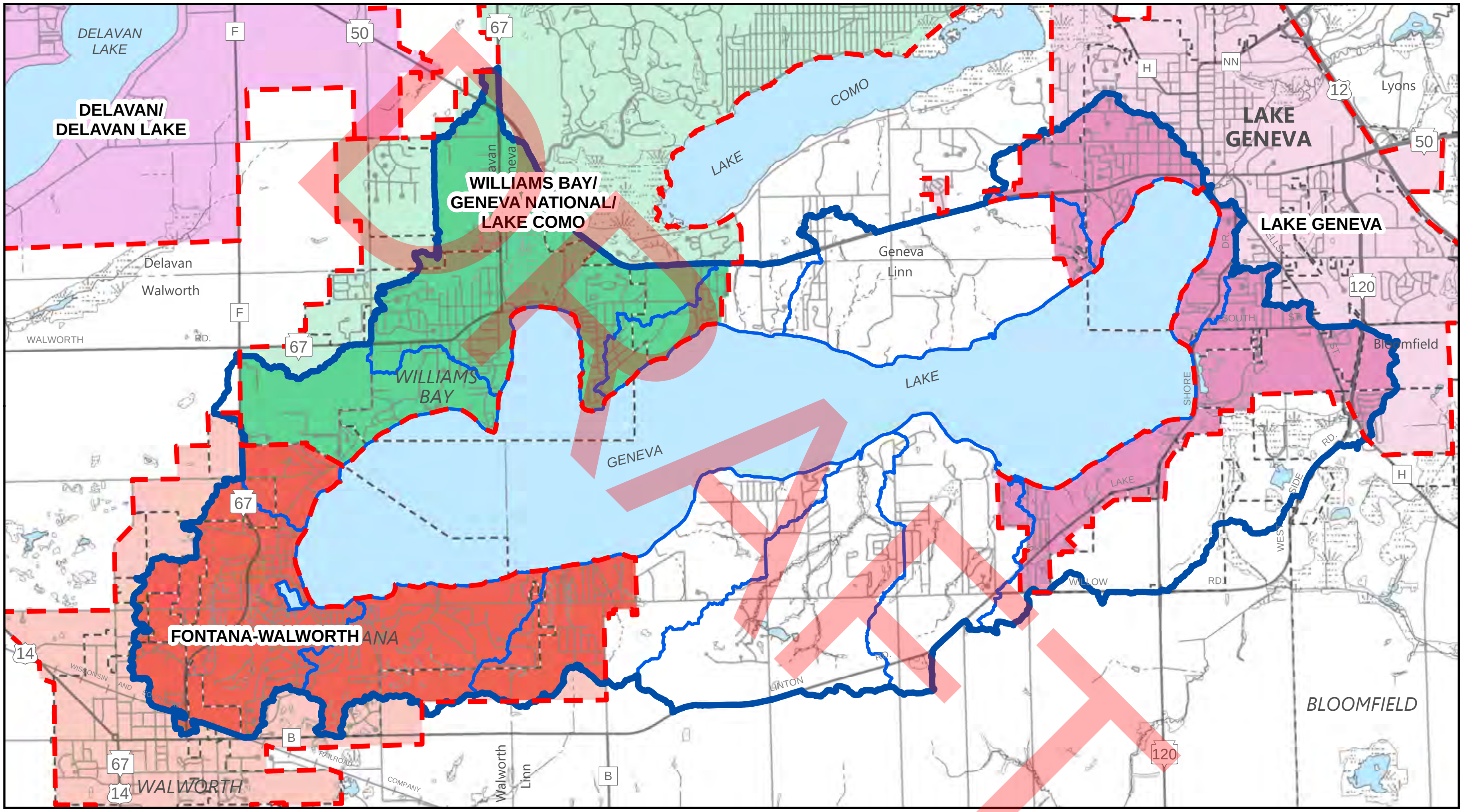
Map 2.8 is an update to Map IX-1 in the 2009 Walworth County Comprehensive Plan.

0 0.5 1 Mile

Last Updated: 02/13/2025

Source: Walworth County, Towns in Walworth County, and Southeastern Wisconsin Regional Planning Commission

Map 2.12
Currently Adopted Sanitary Sewer Service Areas Within the Geneva Lake Watershed: 2024



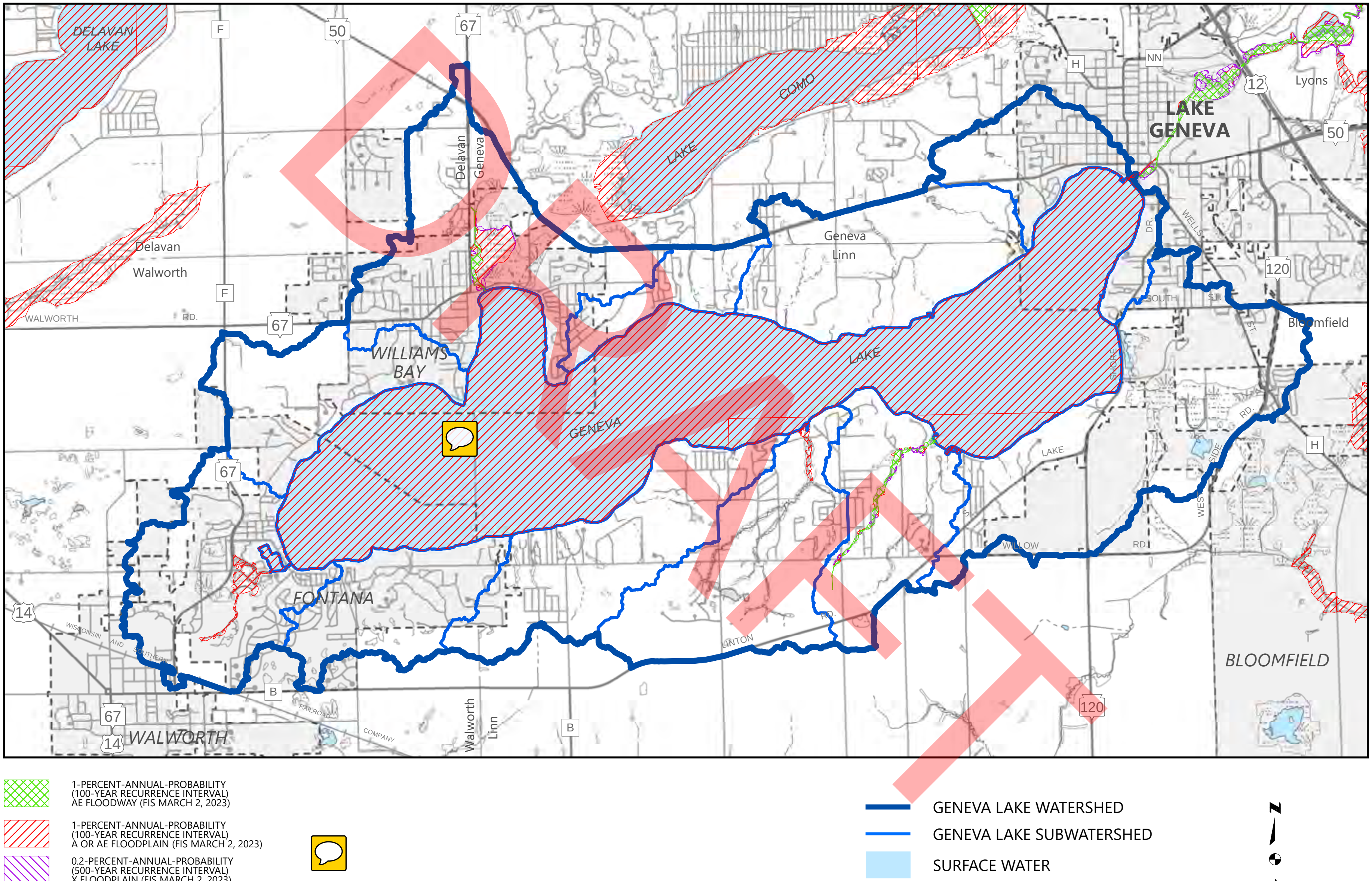
Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

GENEVA LAKE WATERSHED
GENEVA LAKE SUBWATERSHED
SURFACE WATER

0 0.5 1 Mile
Last Updated: 02/13/2025

Source: Southeastern Wisconsin Regional Planning Commission

Map 2.13
Mapped Floodways and Floodplains Within the Geneva Lake Watershed: 2023

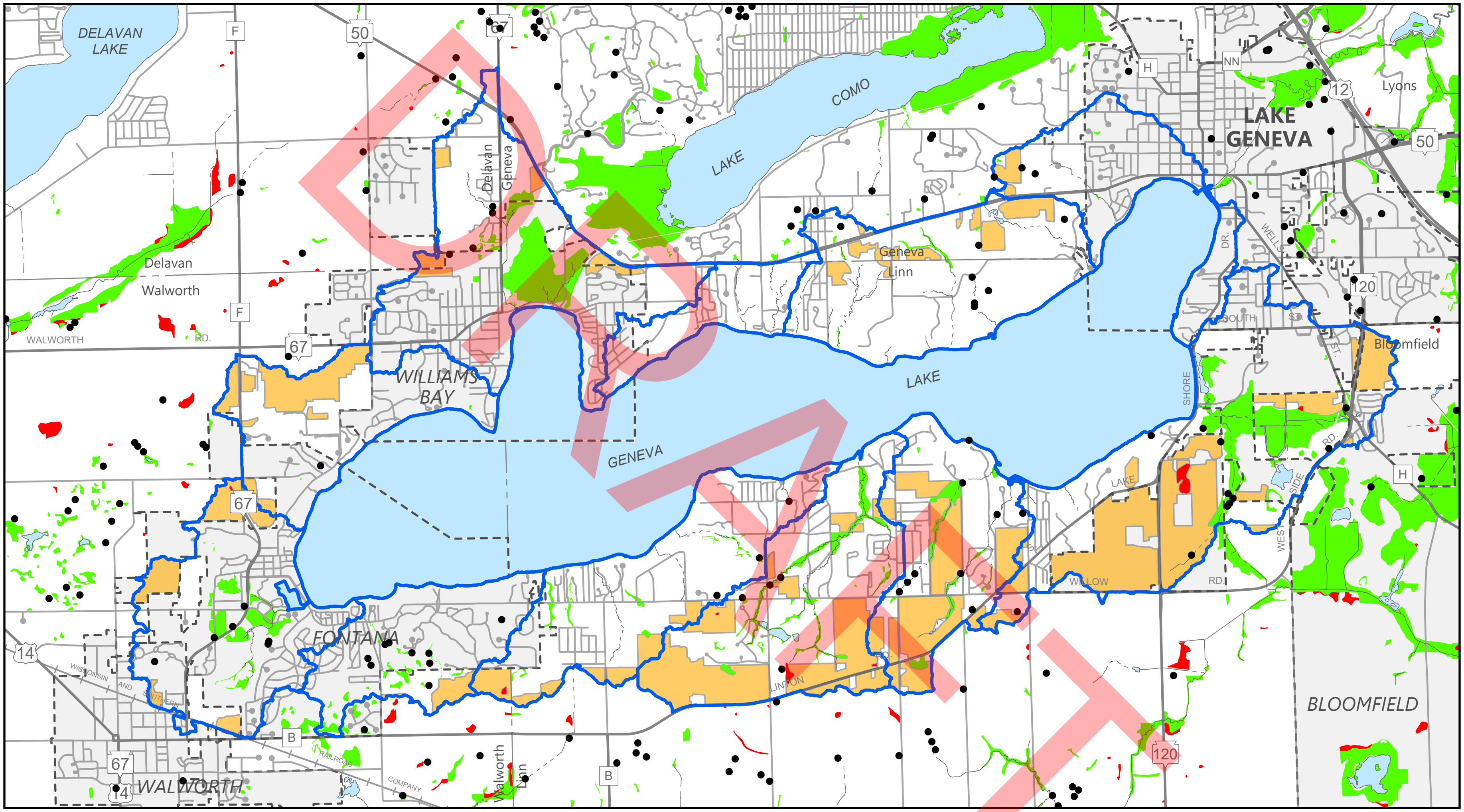


Last Updated: 02/13/2025

Note: The waterbody of Geneva Lake contains both the 100-year and 500-year floodplains.

Source: Federal Emergency Management Agency, Wisconsin Department of Natural Resources, and Southeastern Wisconsin Regional Planning Commission

Map 2.14
Existing, Potentially Restorable, and Farmed Wetlands Within the Geneva Lake Watershed: 2024



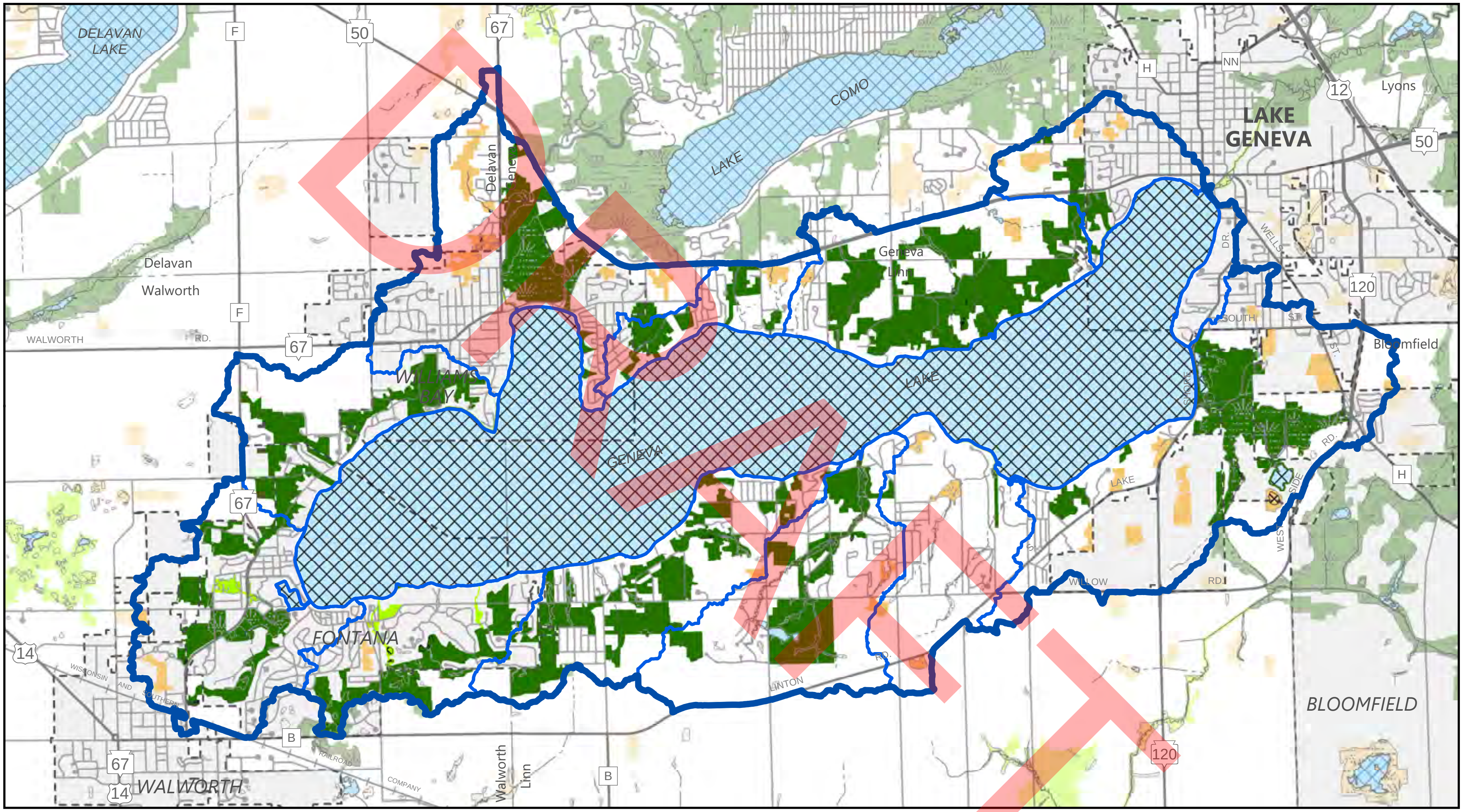
WETLAND
FARMED WETLAND
WETLAND TOO SMALL TO DELINEATE
CULTIVATED LANDS
GENEVA LAKE WATERSHED
GENEVA LAKE SUBWATERSHED
SURFACE WATER

0 0.5 1 Mile

Source: *Wisconsin Department of Natural Resources and Southeastern Wisconsin Regional Planning Commission*

Last Updated: 02/14/2025

Map 2.15
Environmental Corridors and Isolated Natural Resources Areas Within the Geneva Lake Watershed: 2020



PRIMARY ENVIRONMENTAL CORRIDOR (PEC)

SECONDARY ENVIRONMENTAL CORRIDOR (SEC)

ISOLATED NATURAL RESOURCE AREA (INRA)

WATER BODIES WITHIN PEC/SEC/INRA

Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

GENEVA LAKE WATERSHED

GENEVA LAKE SUBWATERSHED

SURFACE WATER

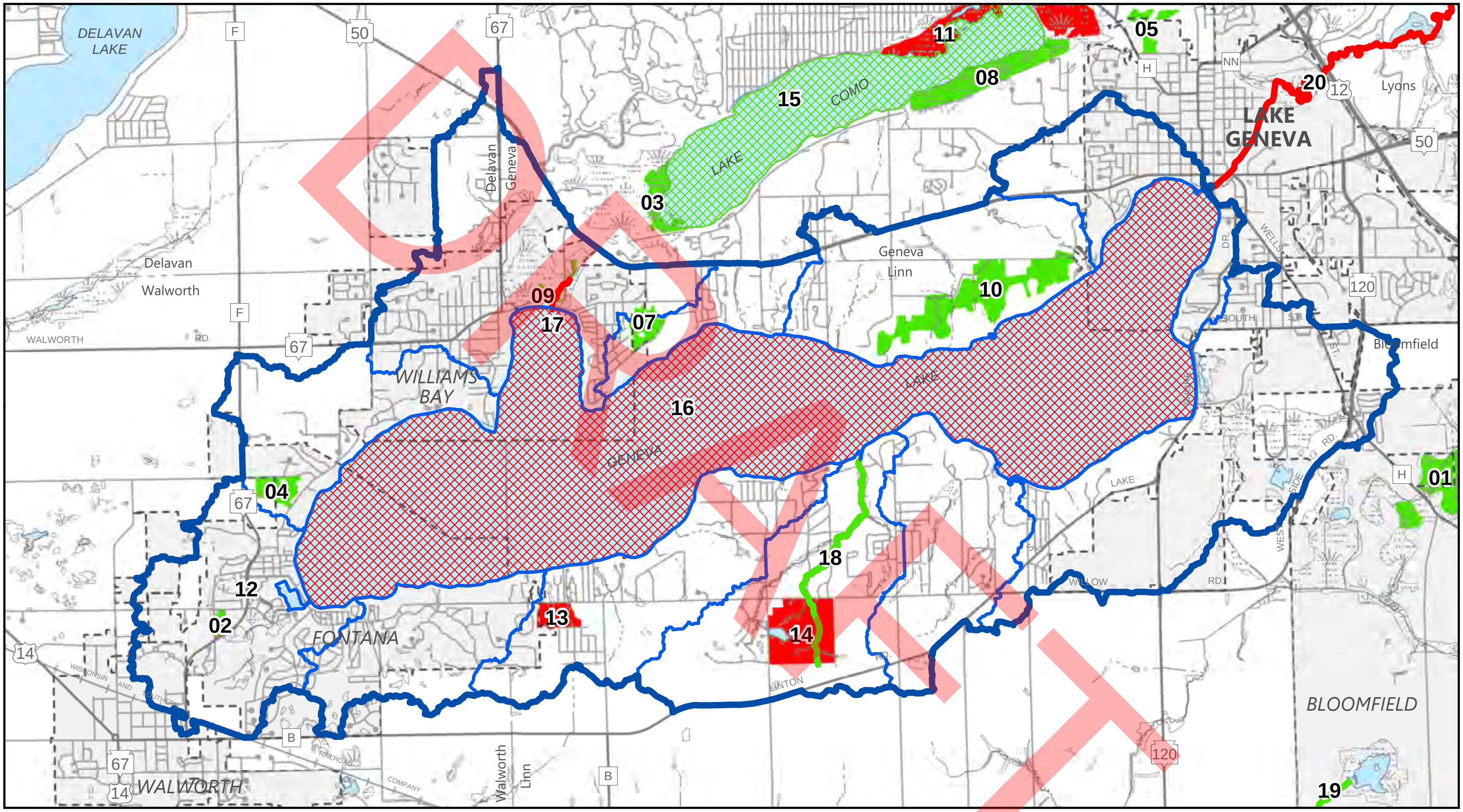
N

0 0.5 1 Mile

Last Updated: 02/14/2025

Source: Wisconsin Department of Natural Resources and Southeastern Wisconsin Regional Planning Commission

Map 2.16
Natural Areas, Critical Species Habitat and Aquatic Area Sites Within the Geneva Lake Watershed: 2024



NATURAL AREAS OF LOCAL SIGNIFICANCE (NA-3)
CRITICAL SPECIES HABITAT SITES
AQUATIC HABITAT AREAS OF STATEWIDE OR GREATER SIGNIFICANCE (AQ-1)
AQUATIC HABITAT AREAS OF LOCAL SIGNIFICANCE (AQ-3)
AQUATIC HABITAT RIVERS OR STREAMS OF COUNTYWIDE OR REGIONAL SIGNIFICANCE (AQ-2)
AQUATIC HABITAT RIVERS OR STREAMS OF LOCAL SIGNIFICANCE (AQ-3)

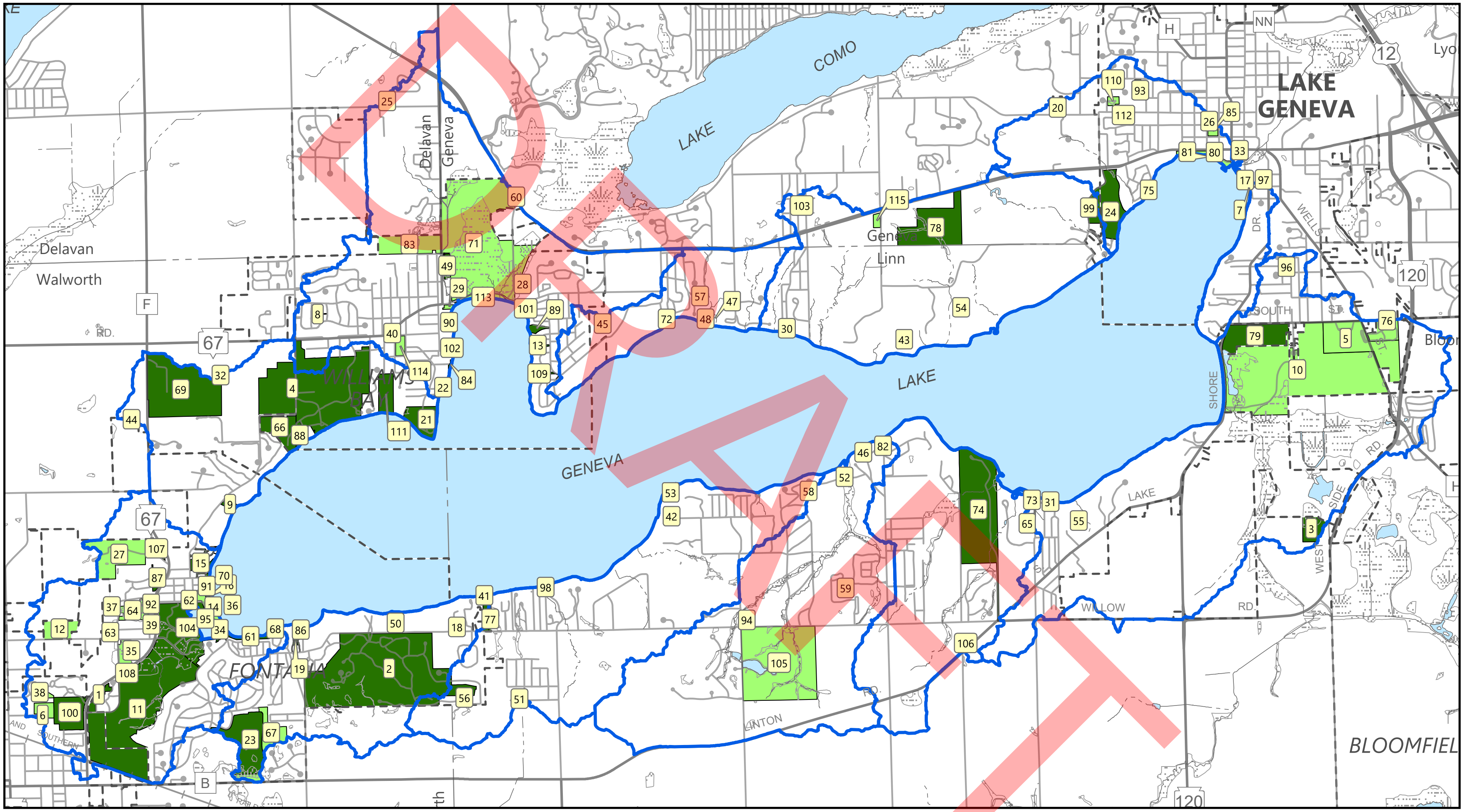
GENEVA LAKE WATERSHED
GENEVA LAKE SUBWATERSHED
SURFACE WATER

0 0.5 1 Mile

Last Updated: 02/14/2025

Source: Southeastern Wisconsin Regional Planning Commission

Map 2.17
Parks and Open Spaces Within Public or Private Protection in the Geneva Lake Watershed



PUBLIC-OWNED SITE

PRIVATE-OWNED SITE

SITE NUMBER

Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

GENEVA LAKE WATERSHED

GENEVA LAKE SUBWATERSHED

SURFACE WATER

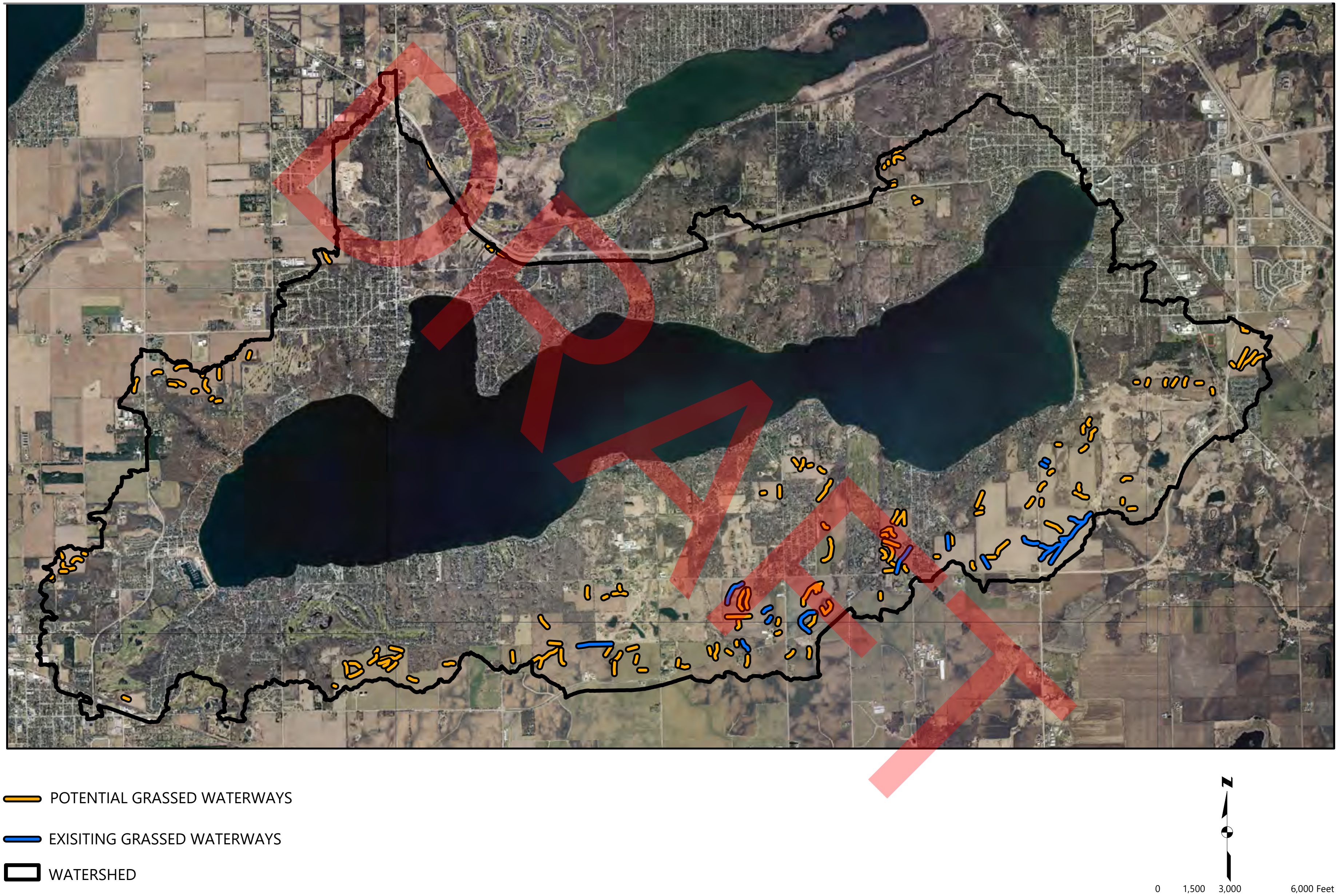
N

0 0.5 1 Mile

Last Updated: 02/13/2025

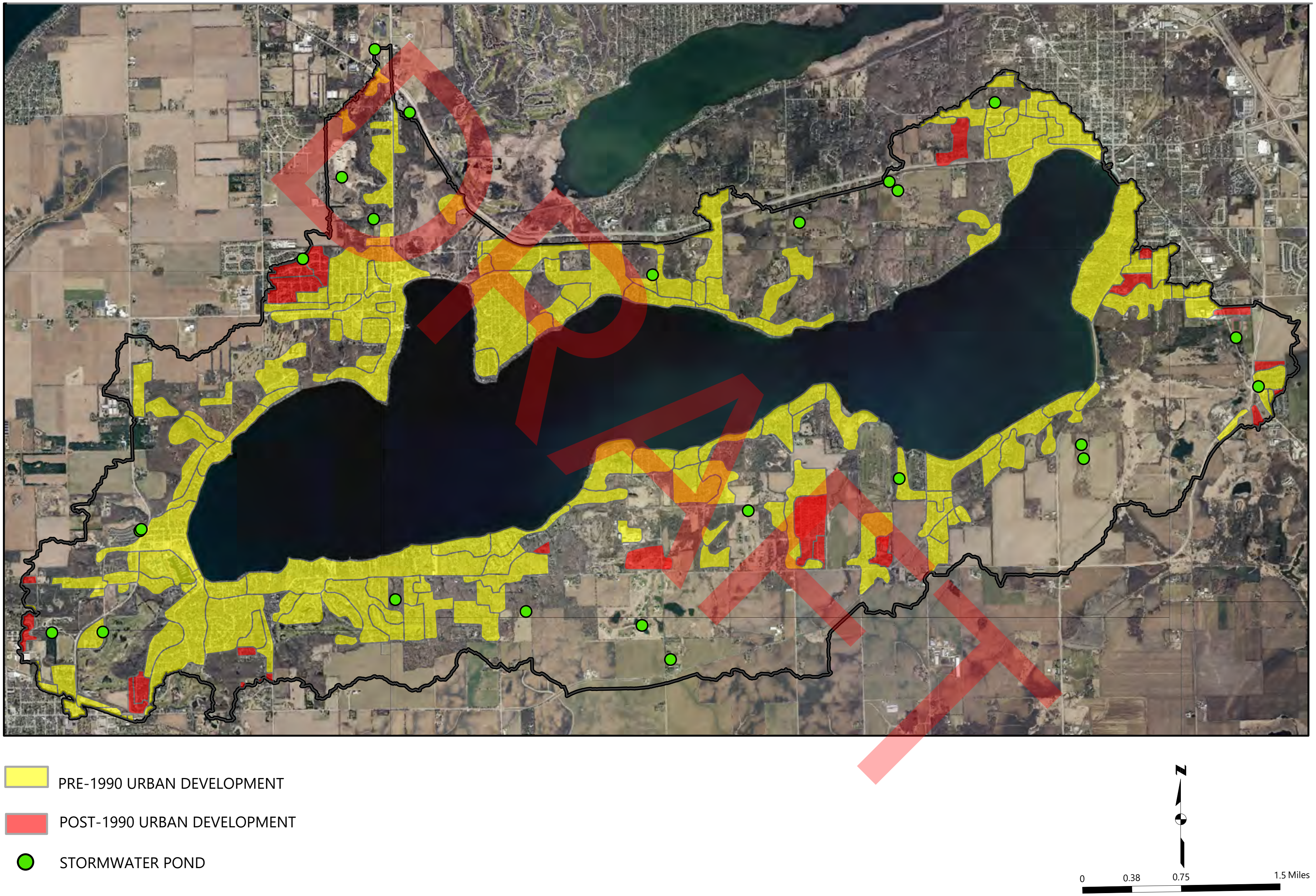
Source: Southeastern Wisconsin Regional Planning Commission

Map 2.18
Identified Existing and Potential Grassed Waterways in the Geneva Lake Watershed



Source: SEWRPC

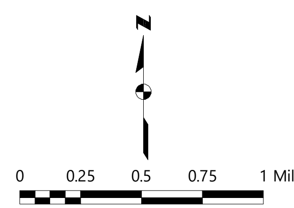
Map 2.19
Stormwater Ponds and Urban Development Within the Geneva Lake Watershed



Source: SEWRPC

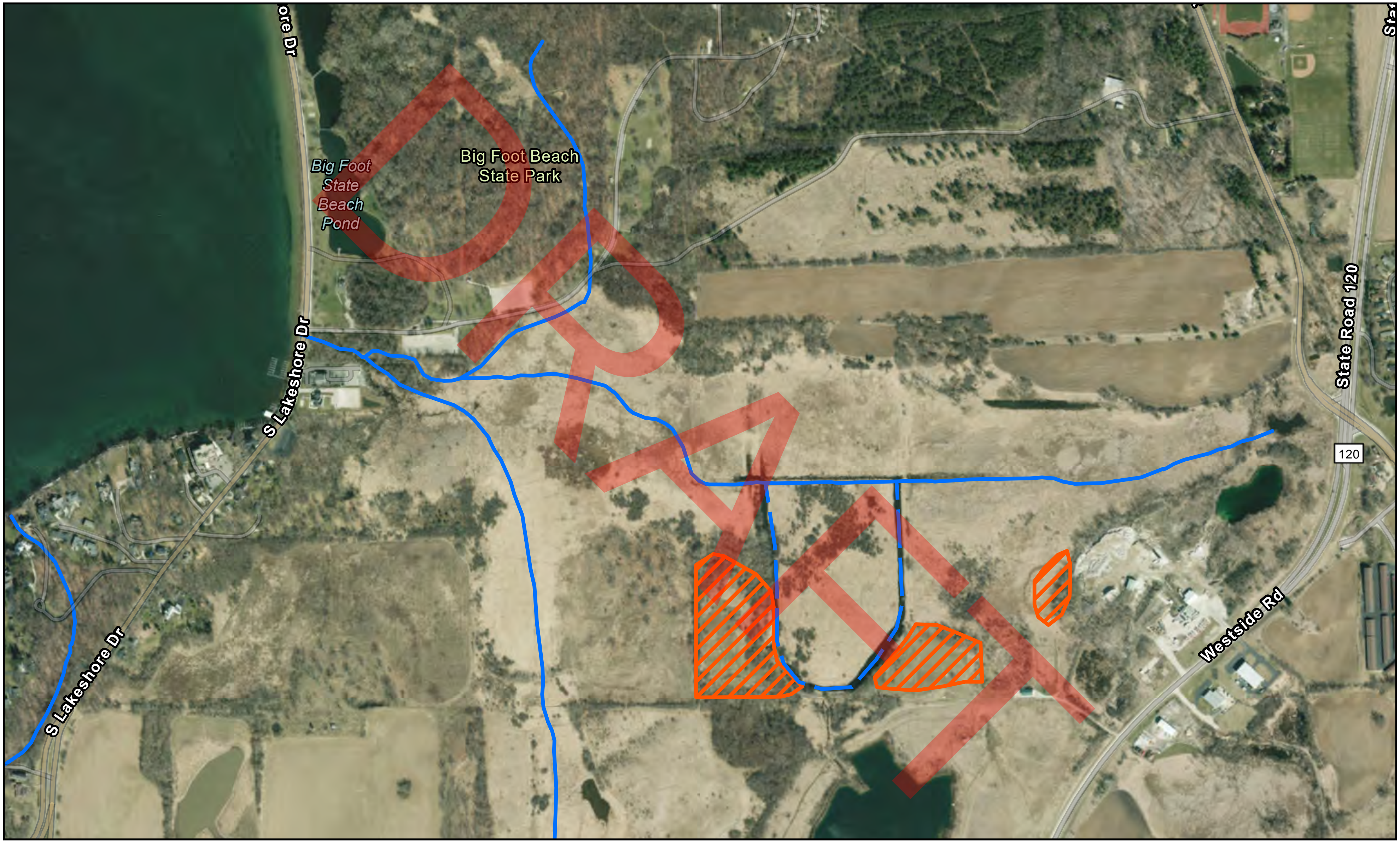
Map 2.20
Geneva Lake Water Quality Monitoring Sites

Note: Date of Photograph 2024



Source: Wisconsin Department of Natural Resources and Southeastern Wisconsin Regional Planning Commission

Map 2.21
Bigfoot Creek Mainstem, "Horseshoe," and Otto Jacobs Landfill Sites



BIGFOOT CREEK

"HORSESHOE"

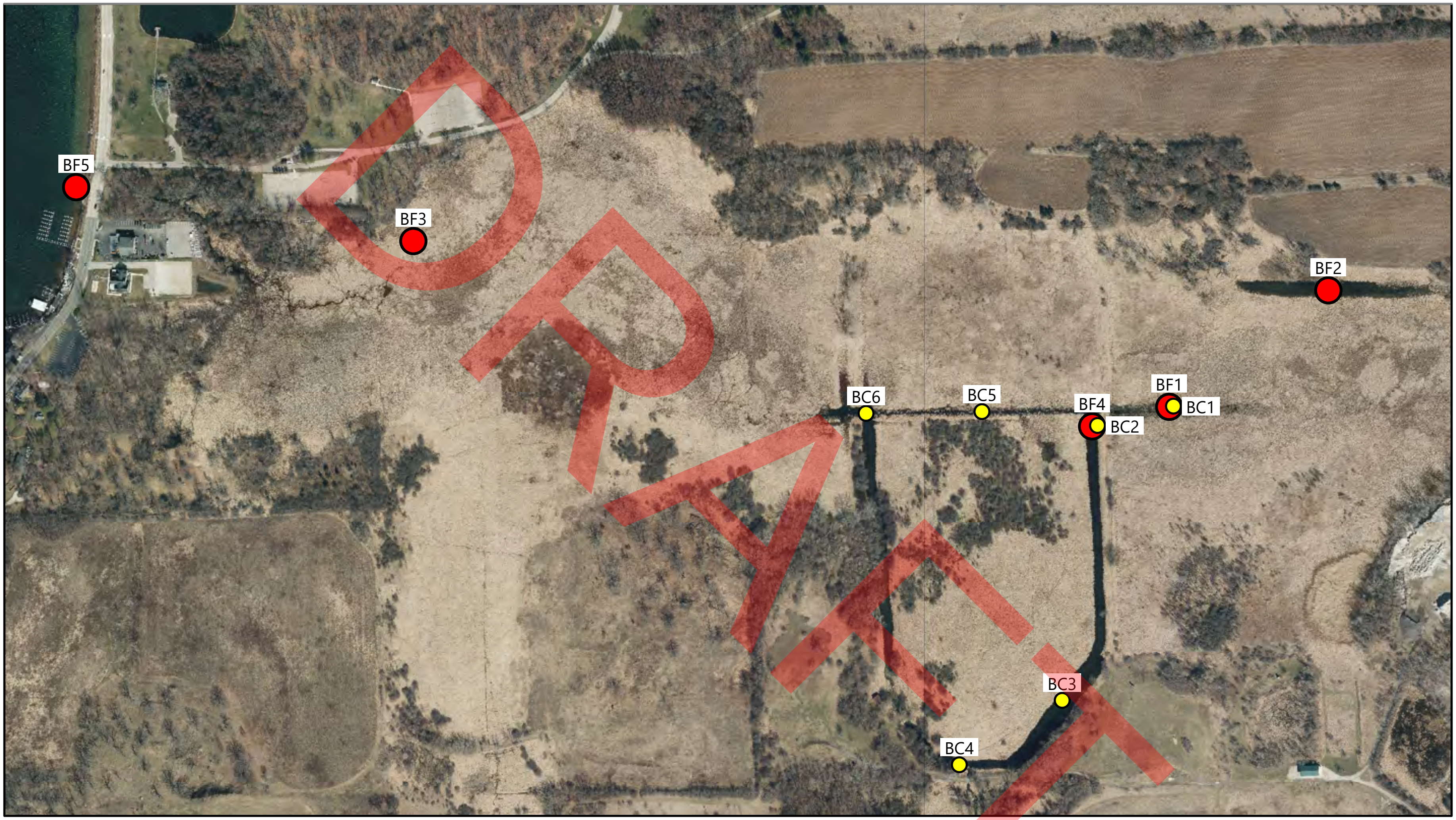
LANDFILL SITES

N

0 187.5 375 750 1,125 Feet

Source: SEWRPC

Map 2.22
2024 Bigfoot Creek Water Quality Sample Locations: 2024



Note: SEWRPC samples were collected on 7/1/2024 and GLC samples were collected on 8/27/2024. Sample locations were approximately the same for BC1 and BF1, as well as BC2 and BF4, respectively.

SAMPLING ENTITY

GLC
SEWRPC

0 150 300 600 Feet

Source: SEWRPC

SEWRPC Community Assistance Planning Report Number 60 (3rd Edition)

A LAKE MANAGEMENT PLAN FOR GENEVA LAKE
WALWORTH COUNTY, WISCONSIN

Chapter 2 Tables

SEWRPC Community Assistance Planning Report Number 60 (3rd Edition)

A LAKE MANAGEMENT PLAN FOR GENEVA LAKE
WALWORTH COUNTY, WISCONSIN

Chapter 2 Figures

Table 2.1
Climate Normals for Delavan Wastewater Treatment Facility: 1991 – 2020 and 2005 – 2020

	1991 - 2020				2006 - 2020				Difference			
Month	**Max. Temp. (°F)**	**Min. Temp. (°F)**	**Average Temp. (°F)**	**Precipitation (inches)**	**Max. Temp. (°F)**	**Min. Temp. (°F)**	**Average Temp. (°F)**	**Precipitation (inches)**	**Change in Max. Temp. (°F)**	**Change in Min. Temp. (°F)**	**Change in Average Temp. (°F)**	**Change in Precipitation (inches)**
Jan	29.2	13.4	21.3	1.56	29.7	13.9	21.8	1.58	0.5	0.5	0.5	0.02
Feb	32.6	16	24.3	1.67	31.1	13.9	22.5	1.86	-1.5	-2.1	-1.8	0.19
Mar	43.7	24.9	34.3	1.97	44	24.9	34.5	2.31	0.3	0	0.2	0.34
Apr	57	35.7	46.4	3.66	56.8	35.7	46.3	3.87	-0.2	0	-0.1	0.21
May	68.8	46.9	57.9	4.19	69.3	47.4	58.4	4.15	0.5	0.5	0.5	-0.04
Jun	79	56.8	67.9	4.96	79	57.1	68.1	5.43	0	0.3	0.2	0.47
Jul	82.9	60.8	71.9	3.79	83.3	61.2	72.3	4.36	0.4	0.4	0.4	0.57
Aug	81.1	58.9	70	3.87	81.3	59	70.2	4.31	0.2	0.1	0.2	0.44
Sep	74.2	51.2	62.7	3.74	74.7	51.9	63.3	3.75	0.5	0.7	0.6	0.01
Oct	60.8	39.5	50.2	2.89	60.5	39.8	50.2	3.36	-0.3	0.3	0	0.47
Nov	46.2	28.9	37.6	2.61	46.9	29.1	38	2.39	0.7	0.2	0.4	-0.22
Dec	34.5	19.6	27.1	1.83	34.9	19.9	27.4	2.35	0.4	0.3	0.3	0.52

Note: The temperature and precipitation values presented in this table are the U.S. Climate Normals calculated by the National Oceanic and Atmospheric Administration using their averaging periods of 1991 – 2020 and 2006 – 2020, as accessed through the following website: https://www.ncei.noaa.gov/access/us-climate-normals/. The difference was calculated as the maximum temperature (max. temp.), minimum temperature (min. temp.), average temperature (average temp.), and precipitation from 2006 – 2020 subtracted from the corresponding information from 1991 – 2020.

Source: NOAA and SEWRPC

Table 2.2
Maximum Elevations of the Geneva Lake Watershed

Subwatershed	Maximum Elevation (feet)
GL-1	1,064
GL-2	1,061
GL-3	1,070
GL-4	1,050
GL-5	1,068
GL-6	1,066
GL-7	1,084
GL-8	1,144
GL-9	1,130
GL-10	1,061
GL-11	1,018
GL-12	961

Source: Wisconsin Geological and Natural History Survey and SEWRPC

Table 2.3
Soil Slopes of the Geneva Lake Watershed

Slope (percent)	Acres of Watershed	Percent of Watershed
0.0-2.0	8,268.62	44.9
2.0-6.0	4,791.61	26.0
6.0-12.0	3,212.63	17.5
12.0-20.0	1,604.50	8.7
>20	529.02	2.9

Source: Wisconsin Geological and Natural History Survey and SEWRPC

Table 2.4
Geneva Lake Tributaries

Map Number	Name[a]	WBIC	Stream Length (ft)	Stream Gradient (%)	Dominant Land Uses
1	Geneva Bay Estates	5041428	6,503.04	3.0	Agricultural, wooded
2	Covenant Harbor	5041371	4,376.93	2.4	Wooded, suburban
3	Unnamed	None	368.62	2.2	Suburban
5	Unnamed	None	1,119.85	6.6	Wooded, large lots
6	Unnamed	None	671.87	8.3	Suburban
7	Unnamed	None	145.50	0.7	Wetland
8	Big Foot Creek	504807, 5041631, 5041573	25,677.72	0.7	Agricultural, wetland
9	Unnamed	5041755	2,728.14	2.7	Wooded, large lots
10	Unnamed	None	675.94	8.4	Large lots
11	Unnamed	None	720.00	8.2	Large lots
12	Loramoor	None	512.41	9.8	Large lots
12.5	Unnamed	None	559.72	3.6	Wooded
13	Unnamed	None	1,453.87	2.8	Wooded, large lots
14	Hillside	None	1,731.05	1.7	Suburban
15	Trinke	5041876	11,106.97	1.6	Agricultural, suburban, golf course
16	Country Club	5041877	9,260.73	1.4	Agricultural, suburban, golf course
17	Birches	758400	63,398.30	1.1	Agricultural, suburban, wooded
18	Unnamed	None	323.28	5.0	Suburban
19	Unnamed	None	1,075.87	3.6	Wooded, suburban
20	Unnamed	None	3,554.20	2.0	Wooded, suburban
21	Unnamed	None	3,248.54	5.0	Wooded, large lots
22	Simms	5041843	9314.11	4.5	Wooded, large lots
23	Shadow Lane/ NWNMA	5041906	5,238.12	4.7	Wooded, suburban
24	Chicago Club	None	5,288.39	5.0	Wooded, suburban
25	Yacht Club	5041899	6,132.13	3.3	Wooded, suburban, golf course
26	Unnamed	None	2,195.87	3.4	Wooded, suburban
27	Unnamed	None	2,665.26	6.0	Wooded, suburban, golf course
28	Abbey Springs	None	3,142.64	1.8	Wooded, suburban, golf course
29	Unnamed	None	1,475.29	2.5	Wooded, suburban, golf course
30	Indian Hills	5041928	4,414.75	2.7	Wooded, suburban, golf course
31A	Potawatomi	758700, 4000049, 4000047	15,950.74	1.9	Wooded, suburban, golf course, coldwater
31B	Van Slyke	758800	4791.82	2.1	Wooded, suburban, coldwater
32	Buena Vista	None	6,032.09	5.0	Agricultural, suburban
33	Unnamed	None	1,924.49	7.7	Wooded, suburban
34	Unnamed	None	225.34	9.8	Suburban
35	Unnamed	None	420.87	8.6	Suburban
36	Unnamed	None	331.73	9.0	Suburban
37	Gardens	5041562	11,604.98	2.4	Agricultural, wooded, suburban
38	Unnamed	None	443.62	0.9	Suburban
38.3	Unnamed	None	1,068.7	6.3	Suburban
38.5	Unnamed	None	165.83	5.4	Suburban
38.7	Unnamed	None	553.45	3.6	Suburban
39	Southwick	758600	13,841.56	1.5	Suburban, wetland
40	Harris	758500	3,782.13	0.5	Wetland
40.5	Unnamed	None	2,323.78	1.0	Suburban, wetland
41	Unnamed	None	1,185.57	3.0	Wooded, large lots
41.3	Unnamed	None	839.70	4.6	Suburban
41.5	Unnamed	None	354.48	5.1	Suburban
41.7	Windwood	None	3,837.27	2.9	Suburban
42	Elgin Club	5041478	7,003.89	3.2	Wooded, large lots

43	Glen Fern	5041508	3,012.80	4.5	Suburban
44	Alta Vista	5041517	3,197.11	4.0	Wooded, large lots
45	Unnamed	None	933.02	5.0	Wooded, large lots
46	Rasin	5041446	10,528.64	2.8	Wooded, large lots
47	Unnamed	None	4,693.44	3.6	Wooded
47.5	Unnamed	None	1,117.23	6.7	Wooded, large lots
48	Unnamed	None	1,962.86	5.1	Wooded, large lots
49	Unnamed	None	526.09	4.9	Wooded
50	Chapin	5041459	11,468.10	2.2	Wooded
Total			296,680.21		

[a] In the absence of official names, Commission staff assigned the name of a nearby road or homeowners association to the Creek to distinguish between some of the unnamed streams in the Lake watershed that are discussed in further detail in the plan.

Source: WDNR and SEWRPC

Table 2.5
Land Use in the Geneva Lake Watershed: 2020

Land Use[a]	Acres	Percent of Total
Urban		
Residential		
Single-Family	3,185.6	17.3
Two-Family	28.2	0.2
Multi-Family	184.9	1
Commercial	91	0.5
Industrial	32.3	0.2
Governmental and Institutional	267.8	1.5
Transportation, Communication, and Utilities	1,098.3	6
Recreational	742.9	4
Other Open Lands- Urban	173.3	0.9
Urban Subtotal	5,804.3	31.6
Rural		
Agricultural	2,647.5	14.4
Other Open Lands	1,050	5.7
Wetlands	689	3.7
Woodlands	2,531.8	13.8
Surface Water	5,494.2	29.9
Extractive	189.3	1
Rural Subtotal	12,601.8	68.4
Total	18,406.1	100.0

[a] *Parking included in associated use.*

Source: SEWRPC

Table 2.6
Parks and Open Spaces in the Geneva Lake Watershed

Site Number	Name	Total Acres[a]
1	Abbey Hill	5.6
2	Abbey Springs Country Club	269
3	Aspen Glo Farms	14.8
4	Aurora University	198.7
5	Badger High School	64.9
6	Badger Park	7.6
7	Baker Park	0.4
8	Baywood Heights Park	2.4
9	Belvadere Park	3.1
10	Big Foot Beach State Park	264.6
11	Big Foot Country Club	199.6
12	Big Foot Nature Study Area	16.4
13	Birch Grove Park	3.1
14	Boat Access	0.6
15	Buena Vista	11.1
16	Chuck's Lakeshore Inn	0.5
17	City Boat Access	0.1
18	Clearsky Lodge	2.1
19	Club Unique	1.6
20	Cobb Park	3.5
21	Conference Point Camp	23.8
22	Congress Club	0.1
23	Country Club Estates Golf Course	52
24	Covenant Harbor Bible Camp and Retreat Center (GLC Easement on Property)	37.5
25	Delevan Animal Park	1.7
26	Denison School	0.4
27	Duck Pond Recreation Area	48
28	East Park	0.8
29	Edgewater Park	1.5
30	Elgin Club	0.8
31	Emma Fleck Memorial Park	0.9
32	Faith Christian School	0.2
33	Flat Iron Park	0.5
34	Fontana Beach	12.4
35	Fontana Fen	10.6
36	Fontana Marine Service	0.6
37	Fontana School	5.1
38	Fox Lane Conservancy	3.4
39	Frog Hollow Miniature Golf	0.8
40	Frost Park	0.3
41	Geneva Lake Boat Company	5.1
42	Geneva Lake Conservancy- Black Point	6.9
43	Geneva Lake Conservancy- Brownstein	2.6
44	Geneva Lake Conservancy- Cobalt Farms	2.2
45	Geneva Lake Conservancy- Colman Woods	28
46	Geneva Lake Conservancy- Geraldson	2.2
47	Geneva Lake Conservancy-Griffith East	1
48	Geneva Lake Conservancy- Griffith West	1.3
49	Geneva Lake Conservancy-Helen Rohner Children's Fishing Park	4.4
50	Geneva Lake Conservancy- Love	4.2
51	Geneva Lake Conservancy- Maple Hills	0.1
52	Geneva Lake Conservancy- McEssy	5.3
53	Geneva Lake Conservancy- Peterson	2.5

54	Geneva Lake Conservancy- Stenning/Dreihaus	36.6
55	Geneva Lake Conservancy-Styburg	21.6
56	Geneva Lake Conservancy-Tameling/Newton	0.2
57	Geneva Lake Conservancy-Windwood	4.7
58	Geneva Lake Conservancy- Wooddale	4.4
59	Geneva Lake Conservancy- Woodstone Prairie	49.8
60	Geneva National Golf Course	1.3
61	Glenwood Springs	4.3
62	Gordy's Marina	0.3
63	Headwaters Park	2.1
64	Hildebrand Conservancy (GLC Easement on Property)	12.6
65	Hillside Drive Boat Access	0.1
66	Holiday Home Camp	25.7
67	HWY B	22.7
68	Indian Hills	0.5
69	Inspiration Center	112
70	Jerry's Marine	0.7
71	Kishwauketoe Nature Conservancy (GLC Easement on Property)	226.7
72	Knollwood Park	1.7
73	Lake Geneva Beach	1
74	Lake Geneva Country Club	122.1
75	Lake Geneva Manor Association Park	0.5
76	Lake Geneva Middle School	15
77	Lake Geneva Yacht Club	2.8
78	Lake Geneva YMCA Camp	62.9
79	Lake Geneva Youth Club	42.3
80	Leatherlips Watersports	0.9
81	Library Park	6.4
82	Linn Pier	1.3
83	Lions Athletic Field/ Grandview Hill	34.07
84	Loch Vista Club	0.8
85	Maple Park	2.9
86	Mohr Public Park	0.6
87	Myron Audino	5.9
88	Norman B. Barr Camp	5.1
89	Oak Grove Park	3.2
90	Oakwood Launch	0.5
91	Pioneer Park	0.8
92	Porter Court Plaza	0.7
93	Price-Freemont Park	5.6
94	Reek School	5.3
95	Reid Park	0.9
96	Rushwood Park	1.9
97	Seminary Park	1.3
98	Shadow Lane Park	0.3
99	Snake Road Adventure Center (GLC Easement on Property)	12.3
100	South Pines Golf Range	28.6
101	Subdivision Park	0.3
102	Summerhaven Subdivision Park	0.5
103	Sunset Hills Subdivision Park	2.7
104	The Abbey (GLC Easement on SE Portion of Property, Wetland Area)	61.9
105	Town of Linn Nature Park (GLC Easement on Property)	161.1
106	Traver School	4.6
107	Triangle	3.4
108	Village of Fontana Park	1
109	Walnut Grove Park	4

110	Water Tower Open Space	2.9
111	Wesley Woods Conference Center	17.2
112	Westgate Tot Lot	0.7
113	Williams Bay Beach	6.3
114	Williams Bay Elementary School	5.4
115	Woods School	2.8
	Total	2,505.7

Note: The total acreage is the combined sum of the acreage of all parcels under site ownership.

Source: SEWRPC

Table 2.7

Stakeholder Types and Roles in the Geneva Lake Watershed

Stakeholder Type	Description	Example Organizations
Local Government	Municipal entities surrounding the Lake that govern the management of public boat launches, support inter-municipal organizations, maintain Lake-focused committees and agencies, provide drinking and wastewater services, and enforce ordinances	City of Lake Geneva Town of Linn - Lake Use Committee - Geneva Lake Environmental Inter-municipal organizations - Geneva Lake Environmental Agency (GLEA) - Geneva Lake Use Committee
Walworth County	Administrative division of local government that provides oversight to larger projects. The County works with citizens and formal groups, such as other governmental entities, for the maintenance and improvement of water health.	Walworth County
Environmental Non-Profits	Non-governmental advocational groups that focus on the Lake and its surrounding watershed. These groups aim to address ecological concerns, promote research, protect lands, fundraise, and assist in the establishment of Lake policies.	Geneva Lake Conservancy (GLC) Geneva Lake Association (GLA) Kiskwauketoe Nature Conservancy
Lake Safety and Law Enforcement	Inter-municipal agencies that serve the Lake to ensure all users are safe to themselves and others. Common duties include rescue and first aid, enforcement of Lake regulations, and response to concerns.	Geneva Lake Police Geneva Lake Water Safety Patrol
Clubs and Marinas	Private organizations that provide a social setting for members. Clubs and marinas provide exclusive benefits and participate in events near and on the Lake.	Lake Geneva Yacht Club Lake Geneva Country Club Abbey Marina
Homeowner and Condominium Associations	Organizations that establish and enforce neighborhood ordinances, provide management of common areas and additional amenities, and provide routine communication to residents. Those with Lake access may perform maintenance and/or apply for WDNR aquatic plant management permits.	Lake Geneva Highlands Cooperative Geneva Bay Estates Homeowners Association Abbey Harbor Condominium Association
Fishing	Public clubs or private groups that promote sport fishing on the Lake through meetings, community events, trips, and educational opportunities.	Lake Geneva Fishing Club Geneva Lake Bait and Tackle Lake Geneva Fishing Guide Service
Boat Rentals and Repairs	Businesses that may provide watercrafts for rental or sale, offer lessons in various watersports, and/or perform boat repair services. These groups are often a first point of contact for many first-time Lake users.	Gordy's Marine Elmer's Lake Geneva Boat Line William's Bay Recreation Department- Paddleboard Rentals
Libraries, Museums, and Schools	Educational entities that may host community-orientated events, store information on the Lake's history, and/or offer classes for Lake-specific learning opportunities	Big Foot High School (Village of Walworth) Lake Geneva Public Library Geneva Lake Museum Geneva Lake Astrophysics and STEAM
Camps and Resorts	Establishments that utilize the Lake's location and natural beauty to provide outdoor recreational opportunities for a diverse range of participants	Lake Geneva Fresh Air Association Lake Geneva Youth Camp Norman Barr Camp
Other Stakeholders	Other businesses and operations not previously mentioned, that depend upon the location of the Lake for their operation.	Lake Geneva Cruise Line Yerkes Observatory Lake Geneva Regional News

Source: SEWRPC

Table 2.8
Ecotourism Adoption Opportunities on Geneva Lake

Tourism Group	Description	Ecotourism Implementation
Tourism Agencies	Promotion of local businesses, outreach and engagement with communities, sponsoring events, budget keeping, and advertisement	Providing separate promotion for environmentally conscious practices around the lake for how local partners employ sustainability; highlighting specific practices and businesses around the Lake (e.g., conservation projects, certifications involving environmental consciousness, or partnerships); reaching out to current contacts and gauging interest for an additional promotion opportunity by providing currently employed eco-practices.
Membership-based Lake Recreation	Watercraft storage, social events, exclusive amenities, and clubhouses	Implement shoreline best management practices, if applicable; maintain/achieve 'Clean Marina' status[a]; utilize permeable pavement in parking lots or other paved surfaces; plant native grasses and flowers in landscaping, favoring those with deep roots for soil stabilization and reduction of runoff; limit fertilizer usage; provide updates to members on eco-friendly practices being used by the club; send reminders during Spring outreach/communications on healthy lake practices
Public Outdoor Recreation Spaces	Beaches, parks, Lake Shore Path, nature conservancies,	Signage, where appropriate (e.g., public restrooms, light poles, benches) that remind visitors about being stewards of the area for cleaning up their trash and waste; providing dog waste stations; bagging grass clippings as turfgrass is mowed to prevent it blowing directly into the Lake
Camps and Organized Outings	Municipal recreation departments and seasonal camps that provide recreation-based experiences for attendees	Inclusion of an educational component on safe watercraft usage and protecting our environment; connection of Lake groups for volunteer shoreline improvement measures for BMP implementation; ensure swimming areas are well-marked for Slow, No Wake
Fishing	Fishing clubs and guide services	Ensure onboard waste is collected and later disposed of at the end of the outing (e.g., fishing lines and bobbers); do not offer/sell lead bobbers; and utilize and or promote electric or hybrid motors
Watercraft Sales and Rentals	Boating/watercraft clubs, tour services, rentals, sales, schools, and marines	Provide boating etiquette waiver for operation of rentals; inclusion of GPS which shows adequate depths for wake-enhanced sports for those participating; offer brochures and signage on boats for safe operation and reminders; and provide electric/hybrid motors

[a] For more information, visit https://wisconsincleanmarina.org/about/

Source: SEWRPC

Table 2.9
Site Conditions in Bigfoot Creek - July 2024

Site Name	Water Color	Transparency (cm)	Sediment type	Water temperature (F)	Dissolved oxygen (mg/l)
BC1	Turbid, Brown	9	Flocculent muck	66.9	0.1
BC2	Turbid, Light Brown	23.4	Gravel, muck	80.1	9
BC3	Mostly Clear, Brown	71	Muck	76.3	5.9
BC4	Turbid, Brown	13.8	Muck over clay	68.7	7.6
BC5	Warm Brown	19.6	Flocculent muck	74.8	0.8
BC6	Brown - Orange	32	Flocculent muck	79.2	0.5
Southwick	Clear	91	Sandy muck		3.4

Source: SEWRPC

Table 2.10
Geneva Lake Aquatic Plant Survey Summaries: 2015 through 2024

Survey Date	Species Richness	Maximum Depth of Colonization (feet)	Littoral Zone Frequency of Occurrence (%)	Average Number of Native Species Per Site	Floristic Quality Index	Mean Coefficient of Conservatism	Survey Average Total Rake Fullness
2015	31	41.60	89.07	2.16	37.14	6.90	1.49
2019	29	32.00	78.83	1.75	29.29	5.54	1.63
2020	28	37.00	73.02	1.55	29.25	5.63	1.21
2022	30	27.00	75.67	1.66	30.45	5.66	1.37
2024	27	29.50	84.25	1.78	29.40	6.13	1.24
Average	29	33.42	80.17	1.78	31.11	5.97	1.39

Source: Wisconsin Department of Natural Resources and SEWRPC

Table 2.11
Examples of Positive Ecological Qualities Associated with a Subset of the Aquatic Plant Species Present in Geneva Lake

Aquatic Plant Species Present	Ecological Significance
Ceratophyllum demersum (coontail)	Provides good shelter for young fish; supports insects valuable as food for fish and ducklings; native
Chara spp. (muskgrasses)	A favorite waterfowl food and fish habitat, especially for young fish; native
Elodea canadensis (common waterweed)	Provides shelter and support for insects which are valuable as fish food; native
Heteranthera dubia (water stargrass)	Locally important food source for waterfowl and forage for fish; native
Myriophyllum spicatum (Eurasian watermilfoil)	None known. Invasive nonnative. Hinders navigation, outcompetes desirable aquatic plants, reduces water circulation, depresses oxygen levels, and reduces fish/invertebrate populations
Najas flexilis (slender naiad)	Important food source for waterfowl, marsh birds, and muskrats; provides food and shelter for fish; native
Najas marina (spiny naiad)	Important food source for waterfowl, marsh birds, and muskrats; provides food and shelter for fish; native
*Potamogeton amplifolius (*large-leaf pondweed*)*	Large nutlets provide valuable waterfowl food; provides excellent fish habitat
Potamogeton crispus (curly-leaf pondweed)	Adapted to cold water; mid-summer die-off can impair water quality; invasive nonnative
Potamogeton gramineus (variable pondweed)	The fruit is an important food source for many waterfowl; also provides food for muskrat, deer, and beaver; native
Potamogeton natans (floating-leaf pondweed)	The late-forming fruit provides important food source for ducks; provides good fish habitat due to its shade and foraging opportunities; native
Potamogeton zosteriformis (flat-stem pondweed)	Provides some food for ducks; native
*Ranunculus aquatilis (*White water crowfoot)	Flowers that give way to fruit provide food or dabbling duck and when growing is shallows can provide food for upland game birds.
Ruppia cirrhosa, (ditch grass)	Excellent source of food and habitat for fishes; foliage and fruit serve as food source for wide variety of waterfowl
Stuckenia pectinata (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish; native
Utricularia spp. (bladderworts)	Stems provide food and cover for fish; native
Vallisneria americana (eelgrass/water celery)	Provides good shade and shelter, supports insects, and is valuable fish food; native

Note: Information obtained from A Manual of Aquatic Plants by Norman C. Fassett, University of Wisconsin Press; Guide to Wisconsin Aquatic Plants, Wisconsin Department of Natural Resources; and, Through the Looking Glass: A Field Guide to Aquatic Plants, Wisconsin Lakes Partnership, University of Wisconsin-Extension.

Source: SEWRPC

Table 2.12
Summary of Historical Aquatic Plant Surveys on Geneva Lake

Common Name	Scientific Name	Relative Frequency of Occurrence[a] (percent)						
		1976	1994	2001	2015	2019	2020	2022
Ceratophyllum demersum	Coontail	2.3	6	3	34.5	31.8	28.2	23.2
Ceratophyllum echinatum	Spiny Hornwort	--	--	--	2.4	--	--	--
Chara sp.	Muskgrass	30.1	23	22.8	30.7	19.4	14.7	12.3
Elodea acicularis	Needle Spikerush	--	--	--	--	0.1	--	--
Elodea canadensis	Elodea (waterweed)	--	3.1	--	1.4	1.1	0.9	1.4
Elodea nuttallii[b]	Elodea (waterweed)	0.3	2	3	--	--	--	--
Heteranthia dubia	Water star-grass	--	2	0.2	2.2	4.9	5.2	10.3
Myriophyllum heterophyllum	Various-leaved watermilfoil	--	--	--	--	1	--	0.1
Myriophyllum sibericum[c]	Northern Watermilfoil	21.1	20	12.7	17.8	7.4	3.6	5.3
Myriophyllum spicatum	Eurasian Watermilfoil	5.1	2	7.2	22.3	25.5	19.5	13.2
Najas flexis	Bushy Pondweed (slender naiad)	2.8	2	2.1	3.5	--	0.5	0.9
Najas gracillina	Bushy Naiad	3.6	--	--	--	--	--	--
Najas guadalupensis	Southern Naiad	--	--	--	0.3	4.6	3.6	1.3
Najas marina	Spiny Naiad	0.1	--	--	--	--	--	--
Nitella obtusa	Starry Stonewort	--	--	--	--	0.1	0.1	1
Nitella sp.	Nitella	--	--	--	1.1	1.5	2.7	1.9
Potamogeton amplifolius	Large-Leaf Pondweed	0.8	0.3	1.3	0.1	0.3	--	--
Potamogeton crispus	Curly-Leaf Pondweed	1.1	1	2.1	4.8	3.1	2.8	0.6
Potamogeton diversifolius	Water-Thread Pondweed	--	--	0.2	--	--	--	--
Potamogeton foliosus	Leafy Pondweed	0.1	0.1	--	--	1.3	4.9	4.7
Potamogeton friesii	Fries' Pondweed	--	--	--	0.8	9.5	6	5.2
Potamogeton gramineus	Variable Pondweed	3.6	3	--	2.9	0.1	0.9	1.6
Potamogeton illinoensis	Illinois Pondweed	--	0.1	7.1	0.6	1.3	0.1	0.9
Potamogeton natans	Floating-Leaf Pondweed	0.2	2	1.3	0.1	0.1	0.1	0.4
Potamogeton nodosus	Long-Leaf Pondweed	0.1	0.1	0.7	0.7	0.8	1.2	1.9

Potamogeton praelongus	White-Stem Pondweed	0.4	0.1	--	--	--	0.3	0.1
Potamogeton pusilis	Small Pondweed	--	--	0.2	--	--	0.1	0.3
Potamogeton richardsonii	Clasping-Leaf Pondweed	0.1	0.6	--	0.3	0.4	--	0.1
Potamogeton robbinsii	Fern Pondweed	--	--	0.2	--	--	--	--
Potamogeton strictifolius	Stiff Pondweed	--	--	--	--	5	6.9	1.3
Potamogeton zosteriformis	Flat-Stem Pondweed	1.9	1	3	26.2	3.6	6.1	5.3
Ranunculus aquatilis (longirostris)	White Water Crowfoot	1.2	0.3	--	1.5	2.7	2.5	4.3
Ruppia sp.	Ditch-grass	--	--	24.8	30.2	31.3	24.7	21.3
Schoenoplectus subterminalis	Water Bulrush	--	--	--	15.4	--	--	--
Stukenia pectinatus	Sago Pondweed	12	14	10.1	10.5	10.9	4.9	8.3
Stukenia sp.	Pondweed	--	--	--	0.4	--	--	--
Utricularia gibba	Creeping Bladderwort	--	--	--	1.1	--	--	--
Utricularia minor	Northern (small) Bladderwort	0.1	--	--	0.4	--	--	--
Utricularia vulgaris	Common Bladderwort	0.6	13	3.8	7.6	1	0.8	1.7
Vallisneria americana	Eel grass	9.6	6.0	19.0	25.0	30.6	36.3	34.1
Total Number of Species		22	22	20	28	27	26	28

Note: In the 1976 survey there were 627 sampling sites along 107 transects. During the 1994 survey, sampling was done along every other transect from the 1977 survey, for a total of 55 transects, with approximately four sampling sites at each transect. During the 2001 survey, there were 135 sampling sites along 27 transects. The surveys done in 2015, 2019, 2020, and 2022 utilized point-intercept.

[a] *The Relative Frequency of Occurrence is the frequency of occurrence of a species divided by the total frequency of all species. This statistic presents an indication of how the plant occurs throughout a lake in relation to each other. The initial (1985) SEWRPC report, these values were reported as Relative Abundance. In the GLEA 1994 report, Geneva Lake's Submergent Macrophyte Community Diversity" by George Johnson, this value was reported as Precent Occurrence.*

[b] *In the 2002 GLEA Report Elodea occidentale, Elodea nuttallii, and Elodea the species are reported as E. nuttallii.*

[c] *Due to difficulty in differentiating Myriophyllum heterophylum from Myriophyllum sibiricum, the 2001 GLEA report grouped the two species together; to be consistent with the 1977 report, the species are reported as Myriophyllum sibiricum.*

Source: SEWRPC, GLEA, WDNR

Table 2.13
Geneva Lake Aquatic Plant Survey Summaries: 2015 through 2024

Survey Date	Species Richness	Maximum Depth of Colonization (feet)	Littoral Zone Frequency of Occurrence (%)	Average Number of Native Species Per Site	Floristic Quality Index	Mean Coefficient of Conservatism	Survey Average Total Rake Fullness
2015	31	41.60	89.07	2.16	37.14	6.90	1.49
2019	29	32.00	78.83	1.75	29.29	5.54	1.63
2020	28	37.00	73.02	1.55	29.25	5.63	1.21
2022	30	27.00	75.67	1.66	30.45	5.66	1.37
2024	27	29.50	84.25	1.78	29.40	6.13	1.24
Average	29	33.42	80.17	1.78	31.11	5.97	1.39

Source: Wisconsin Department of Natural Resources and SEWRPC

Table 2.14
Zooplankton found in Geneva Lake

Type	Name[a]		
Zooplankton	Alona costata	Diaphanosoma brachyurum	Harpacticoid copepod
	Bosmina longirostris	Diaptomid copepodites	Ilyocryptus sp. (NSp)
	Camptocercus rectirostris	Diaptomus pallidus	Immature Daphnia
	Ceriodaphnia dubia	Diaptomus siciloides	Leptodora kindti
	Chaoborus larvae	Difflugia sp. 1	Mesocyclops edax
	Chydorus sphaericus	Difflugia sp. 2	Microcyclops varicans
	Copepod nauplii	Difflugia sp. 3	Ophryoxus gracilis
	Cyclopoid copepodites	Ergasilius sp.	Pleuroxus sp
	Cyclops bicuspidatus thomasi	Eubosmina coregoni	Simocephalus serrulatus
	Daphnia longiremis	Gastropus stylifer	Tropocyclops prasinus
	Daphnia retrocurva	Graptoleberis testudinaria	

Note: Other miscellaneous species collected included *Bivalve glochidia*, chironomid larvae, fish eggs, nematodes, ostracods, tardigrades, and watermites.

[a] Where species-level identification was not possible, 'sp.' is listed after the genus.

Sources: GLEA and SEWRPC

Table 2.15
Rotifers found in Geneva Lake

Type	Name[a]		
Rotifers	Aneuropsis fissa	Euchlanis sp.	Notholca squamula
	Ascomorpha ecaudis	Filinia longiseta	Peritrich colonies
	Ascomorpha ovalis	Gastropus stylifer	Philodina sp.
	Ascomorpha saltans	Hexarthra sp.	Platyias quadricornis
	Asplanchna priodonta	Kellicottia longispina	Ploesoma truncatum
	Bdelloid rotifer	Keratella cochlearis	Polyarthra doliochoptera
	Brachionus budapestine	Keratella hiemalis	Polyarthra euryptera
	Brachionus budapestinensis	Keratella irregularis	Polyarthra remata
	Brachionus calyciflorus	Keratella quadrata	Polyarthra vulgaris
	Brachionus caudatus	Lecane luna	Pompholyx sulcata
	Brachionus rubens	Lepadella acuminata	Synchaeta pectinata
	Brachionus variabilis	Monostyla lunaris	Testudinella parva
	Cephalodella sp.	Monostyla sp.	Trichocerca cylindrica
	Collotheca pelagica	Mytilina ventralis	Trichocerca longiseta
	Collotheca sp.	Notholca acuminata	Trichocerca multicrinis
	Colonial peritrich ciliate	Notholca labis	Trichocerca similis
	Conochiloides dossuarius	Notholca laurentiae	
	Conochiloides natans	Notholca michiganensis	

Note: Other miscellaneous species collected included *Bivalve glochidia*, chironomid larvae, fish eggs, nematodes, ostracods, tardigrades, and watermites.

[a] *Where species-level identification was not possible, 'sp.' is listed after the genus.*

Sources: GLEA and SEWRPC

Table 2.16
Examples of Positive Ecological Qualities Associated with Fish Species Present in Geneva Lake[a,b]

Scientific Name	Ecological Significance
Ambloplites rupestris (rock bass)	Carnivore; desirable sport fish; native
Ameiurus melas (black bullhead)	Carnivore; tolerant to a wide variety of environments such as poorly oxygenated, polluted, and/or high temperature waters; desirable sport fish
Ameiurus natalis (yellow bullhead)	Carnivore; bottom dwellers with a high tolerance for pollution; native
Ameiurus nebulosus (brown bullhead)	Opportunistic omnivores; prey for larger predatory fishes; used as an indicator species in pollution studies; native
Amia calva (bowfin)	Non-specific predator fish; rarely eaten as prey of other predators; native
Campostoma anomalum (central stoneroller)	Herbivore; primarily consumes filamentous algae; native
Catostomus commersonii (white sucker)	Omnivore; bottom feeder; prey of other predatory fishes; highly tolerant of polluted, murky, and anoxic waters; native
Coregonus artedi (cisco)	Planktivore; desirable nutrient-dense prey for predator fish; most important Geneva Lake forage fish; requires deep, cool, and infertile waters for habitation; native
Culaea inconstans (brook stickleback)	Carnivore; common prey species for larger predator fishes; native
Cyprinus carpio (carp)	Omnivore; hardy fish that can survive in a wide range of environments; decrease water quality by resuspending sediment and consuming and consequently excreting bioavailable nutrients; introduced non-native
Erimyzon sucetta (lake chubsucker)	Bottom feeder; bulk of diet consists of filamentous algae; native
Esox lucius (northern pike)	Carnivore; larvae serve as a food source for smaller fishes; tolerant to varying water temperatures, clarity, and dissolved oxygen; desirable sport fish; native
Esox masquinongy (muskellunge)	Carnivore and top predator; larvae serve as a food source for smaller fishes; adaptable to varying temperatures, though need clear waters; desirable sport fish; native
Ethostoma caeruleum (rainbow darter)	Bottom feeder that consumes primarily filamentous algae; native
Ethostoma exile (iowa darter)	Carnivore; prey to larger predator fishes; native
Ethostoma flabellare (fantail darter)	Carnivore; prey to other predator fishes; native
Ethostoma microperca (least darter)	Carnivore; prey to other predator fishes; native
Ethostoma nigrum (johnny darter)	Carnivore; tolerant to a range of habitat conditions; prey to other predator fishes; native
Fundulus diaphanous menona (Western banded killifish)	Omnivore; consume plant and invertebrate material; native
Lepisosteus osseus (longnose gar)	Top predator; carnivore; obligate host (all gar species) to the glochidia of native freshwater sandshell mussels; native
Lepomis cyanellus (green sunfish)	Carnivore; tolerant to a range of habitat and water conditions; prey of larger predator fish; native
Lepomis gibbosus (pumpkinseed)	Insectivore; particularly diverse feeder; eat mosquito larvae and has been used as a control measure to reduce mosquito populations; common prey to larger predator fishes and birds; desirable sport fish; native
Lepomis macrochrirus (bluegill)	Insectivore, though adaptable to consume more plant material in times when other sources are limited; native
Luxilus cornutus (common shiner)	Omnivore; prey for larger predator fishes; tolerant to a wide variety of habitats; native
Micropterus dolomeiu (smallmouth bass)	Predator; larvae serve as a food source for smaller fish; desirable sport fish; native
Micropterus salmoides (largemouth bass)	Carnivore and top predator; desirable sport fish; native
Notemigonus crysoleucas (golden shiner)	Omnivore; high plankton consumption aids in decrease of eutrophication of waters; native
Notropsis atherinoides (emerald shiner)	Omnivore; prey fish of larger predators; mainly consumes insects; native
Notropsis hudsonius (spottail shiner)	Carnivore; prey fish of larger predators; tolerant to varying clarity; native
Notropsis spilopterus (spotfin shiner)	Carnivore; prey fish of larger predators; tolerant of habitat variation; native
Notropsis volucellus (mimic shiner)	Omnivore; prey fish of larger predators; important forage fish for Geneva Lake; native
Perca flavescens (yellow perch)	Omnivore; prey fish of larger predators; able to tolerate low oxygen conditions; native
Pimephales notatus (bluntnose minnow)	Omnivore; prey fish of larger predators; habitat needs clear, rocky, shallow areas of streams and lakes; native

Pimephales promelas (fathead minnow)	Omnivore that can be characterized as benthic filter feeders; tolerant to muddy and low oxygen environments that aid in protection against predators which are intolerant to the habitat; native
Pomoxis nigromacrolatus (black crappie)	Carnivore; prey fish to larger predators; able to consume food from surface to mid-waters for a high-variety diet; desirable sport fish; native
Salmo gairdneri (rainbow trout)	Predator; larvae serve as a food source for smaller fishes; presence indicative of high water quality; most tolerant of varying environments of all trout species; desirable sport fish; introduced non-native
Salmo trutta (brown trout)	Predator; larvae serve as a food source for smaller fishes; presence indicative of high quality waters, as cold, clear water is needed for spawning and survival; desirable sport fish; introduced non-native
Salvelinus fontinalis x Salvelinus namaycush (splake)	Predator; larvae serve as a food source for smaller fishes; as a hybrid, it is more tolerant of habitat conditions than other trout; desirable sport fish; native
Salvelinus namaycush (lake trout)	Predator; larvae serve as a food source for smaller fishes; presence indicative of high quality waters as cold, clear water is needed for spawning and survival; popular sport fish; native
Semotilus atromaculatus (creek chub)	Carnivore; prey to larger predatory fish; native
Stizostedion vitreum (walleye)	Predator; larvae serve as a food source for smaller fishes; key fish for predator-prey balance; inhabit shallow to moderately deep waters and tolerant of a range of water temperatures; native

Note: Information obtained from Fishes of Wisconsin by George C. Becker, University of Wisconsin Press; SEWRPC Community Assistance Planning Report No. 60, 2nd Edition, A Lake Management Plan for Geneva Lake, Walworth County, Wisconsin, May 2008; Roffler, Luke. Krall, Josh. Merley, Sean. Comprehensive Fisheries Survey Report of Geneva Lake – Walworth County 2015 Wisconsin Department of Natural Resources; and, Marshall, David. Larson, Tim. Boucher, Robert. 2024 Geneva Lake Nearshore Fishery Survey and Lake Education Event. July 2024.

[a] Species captured in this table are sourced from recent available data and surveys conducted in Geneva Lake. Therefore, some species may not be captured in this table due to the available dataset.

[b] *Lepomis megalotis* (longear sunfish), *Notropis heterolepsis* (blacknose shiner), and *Notropis anogenus* (pugnose shiner) were last reported to be seen with declining populations in a 2004 fisheries inventory cited in the second edition of this plan. They not been inventoried in any following studies.

Source: GLEA, DNR, and SEWRPC

Table 2.17
Fish Stocking in Geneva Lake: 1957-2024

Year	Fish Species Stocked							
	Brown Trout (*Salmo trutta*)	Lake Trout (*Salvelinus namaycush*)	Muskellunge (*Esox masquinongy*)	Northern Pike (*Esox lucius*)	Rainbow Trout (*Salmo gairdneri*)	Smallmouth Bass (*Micropterus dolomieu*)	Splake (*Salvelinus fontinalis x Salvelinus namaycush*)	Walleye (*Stizostedion vitreum*)
1957	4,919	--	--	--	47,260	--	--	49,500
1958	--	--	--	--	394	--	--	49,500
1959	--	--	--	--	--	--	--	11,900
1960	--	--	--	670	--	--	--	--
1961	--	--	--	--	62,129	1,000	--	--
1962	--	--	--	--	--	6,800	--	--
1966	--	--	--	--	--	110,200	--	--
1967	--	--	--	--	--	105,600	--	--
1968	--	--	--	--	--	184,525	--	--
1972	100,350	--	--	--	--	--	--	--
1973	--	14,870	--	--	--	--	--	--
1974	--	20,000	--	--	--	--	--	--
1975	--	15,000	--	--	--	--	--	--
1976	--	47,000	--	--	--	--	--	--
1982	--	1,800	--	--	--	--	--	110,936
1983	--	3,100	--	1,300	--	--	--	--
1984	2,000	13,000	--	--	--	--	--	101,026
1985	2,000	20,000	--	2,500	--	--	--	--
1986	--	16,500	--	--	--	--	--	100,000
1987	6,000	1,050	--	--	--	--	--	--
1988	4,000	--	--	--	--	--	--	--
1989	--	--	--	--	--	--	--	102,802

1990	2,000	--	--	--	2,250	--	--	--
1991	3,000	20,000	--	--	--	--	--	96,462
1992	20,000	34,290	--	2,500	--	--	20,000	--
1993	3,000	--	--	--	--	--	--	93,904
1994	3,000	--	--	819	--	--	--	--
1995	--	19,925	--	--	--	--	--	110,185
1996	6,000	37,714	--	--	--	--	--	--
1997	5,000	45,550	--	--	--	--	--	47,400
1998	3,000	20,000	--	--	--	--	--	3,755
1999	3,000	20,000	--	--	--	--	--	3,755
2000	3,000	12,000	--	--	--	--	--	--
2001	16,000	20,000	--	--	--	--	--	275,415
2002	14,302	18,804	--	--	--	--	--	--
2003	12,000	22,949	--	--	--	--	--	247,369
2004	12,000	76,413	--	--	--	--	--	--
2005	16,412	31,122	--	--	--	--	--	238,132
2006	12,000	26,749	--	--	--	--	--	--
2007	26,310	--	--	--	--	--	--	--
2008	28,000	--	--	--	--	--	--	--
2009	26,541	55,205	--	--	--	--	--	--
2010	17,608	--	3,492	--	--	--	--	188,966
2011	27,000	21,458	--	--	--	--	--	177,651
2012	24,995	31,035	4,990	--	--	--	--	--
2013	25,239	32,560	--	--	--	--	--	--
2014	28,671	39,581	2,499	--	--	--	--	4,784,962
2015	22,203	36,446	--	--	--	--	--	3,888,020
2016	24,997	41,306	2,245	--	--	--	--	4,130,000
2017	28,012	40,446	2,498	--	--	--	--	107,962

2018	14,335	38,299	2,817	--	--	--	--	--
2019	13,413	37,016	2,506	--	--	--	--	105,681
2020	14,087	36,577	--	--	21,643	--	--	--
2021	14,300	27,648	3,691	--	--	--	--	108,103
2022	1,301	32,854	--	--	--	--	--	--
2023	1,273	26,800	2,275	--	--	--	--	42,420
2024	1,786	33,400	3,849	--	--	--	--	--

Note: No fish were stocked in Geneva Lake in the following years and are therefore not included in the table: 1963, 1964, 1965, 1969, 1971, 1977, 1978, 1979, and 1980.

Source: WDNR and SEWRPC

Table 2.18
2025 Fishing Regulations and Management on Geneva Lake

Fish	Season	Regulation	Fishery, Population, or Ecosystem-Level Objective
Bullheads	Open all year	No minimum length limit and the daily bag limit is unlimited	Reduce population density
Catfish	Open all year	No minimum length limit and the daily bag limit is 10	Sustain/increase densities; maintain current conditions
Cisco and Whitefish	Open all year	No minimum length limit and the daily bag limit is 10	Sustain/increase densities; maintain current conditions
Lake Sturgeon	Closed	No fishing allowed	Increase population density
Largemouth Bass and Smallmouth Bass	May 3, 2025 to March 1, 2026	The minimum length limit is 14" and the daily bag limit is 5	Sustain/increase densities; maintain current conditions
Muskellunge and Hybrids	May 3, 2025 to December 31, 2025	The minimum length limit is 50" and the daily bag limit is 1	Maintain/increase densities of moderate/large adults; improve reproduction; increase predation beyond current condition; increase survival/density of large/old individuals; maximize predation on smaller fishes
Northern Pike	May 3, 2025 to March 1, 2026	No minimum length limit and the daily bag limit is 5	Utilize self-sustained, high-density, slow-growing populations; maximize yield; reduce predation/competition
Paddlefish	Closed	No fishing allowed	Increase population density
Panfish	Open all year	No minimum length limit and the daily bag limit is 25	Utilize self-sustained, high-density, slow-growing populations; maximize yield; reduce predation/competition
Rock, Yellow, and White Bass	Open all year	No minimum length limit and the daily bag limit is unlimited	Reduce population density
Rough Fish	Open all year	No minimum length limit and the daily bag limit is unlimited	Reduce population density
Round Goby	Open all year	The daily bag limit is 0, one may be killed and possessed for transport to the WDNR office	Nonnative species not currently found in the Lake. If caught, bring the specimen to WDNR office for identification confirmation.
Ruffe	Open all year	The daily bag limit is 0, one may be killed and possessed for transport to the WDNR office	Nonnative species not currently found in the Lake. If caught, bring the specimen to WDNR office for identification confirmation.
Shovelnose Sturgeon	Closed	No fishing allowed	Increase population density
Walleye, Sauger, and Hybrids	May 3, 2025 to March 1, 2026	The minimum length limit is 18" and the daily bag limit is 3	Maintain/increase density of moderate/large adults; improve reproduction; increase predation beyond current conditions
White Perch	Open all year	The daily bag limit is 0, one may be killed and possessed for transport to the WDNR office	Nonnative species not currently found in the Lake. If caught, bring the specimen to WDNR office for identification confirmation.
Lake Trout	January 4, 2025 to September 30, 2025	The minimum length limit is 17" and the daily bag limit is 2	Maintain/increase density of moderate/large adults; improve reproduction; increase predation beyond current conditions
Brook, Brown, and Rainbow Trout	May 3, 2025 to March 1, 2026	The minimum length limit is 8" and the daily bag limit is 3	Maintain/increase density of moderate/large adults; improve reproduction; increase predation beyond current conditions

Source: WDNR and SEWRPC

Table 2.19
Examples of Boating Businesses Near Geneva Lake

Business Name	Address
Gage Marine	1 Liechty Dr, Williams Bay, WI 53191
The Boat House	N2062 S Lake Shore Dr, Lake Geneva, WI 53147
Marina Bay Boat Rentals	300 Wrigley Dr, Lake Geneva, WI 53147
Elmer's Lake Geneva Boat Line	195 Wrigley Dr, Lake Geneva, WI 53147
Wake the Lake	529 W Main St, Lake Geneva, WI 53147
Anchors Away	Dodge St, Lake Geneva, WI 53147
Carefree Boat Club	Baker House Pier, 327 Wrigley Dr, Lake Geneva, WI 53147
Munson Ski & Marina	W5749 Co Rd B, Walworth, WI 53184
Gordy's Lakefront Marine Boat Rentals	320 Lake St, Fontana-On-Geneva Lake, WI 53125
Lake Geneva Marina Co.	454 Lake St, Fontana-On-Geneva Lake, WI 53125
Lake Geneva Yacht Club	1250 S Lake Shore Dr, Fontana-On-Geneva Lake, WI 53125
Abbey Springs Yacht Club	1 Country Club Dr, Fontana-On-Geneva Lake, WI 53125
Jerry's Majestic Marine	N1599 Maple Ridge Rd, Lake Geneva, WI 53147
Tortola Marine Management	712 W Main St, Lake Geneva, WI 53147
Geneva Lake Sailing School	1250 S Lake Shore Dr, Fontana-On-Geneva Lake, WI 53125

Note: This is not a comprehensive list of businesses that rely on the Lake.

Source: SEWRPC

Table 2.20
Boating Problems as Reported in 1989-1990 Wisconsin Boating Study

Problem	Percent (%) Respondents Rating Problem as Moderate or Serious
Excessive speed of power boats	37
Excessive horsepower of power boats	35
Conflicts with personal watercraft	33
Inconsiderate behavior of others	31
Poor water quality, habitat destruction	30
Garbage (cans, bottles, etc.) in the water	27
Lack of parking lots at access sites	26
Poor design and condition of boat launch ramps at public water access sites	25
Lack of public water access sites	23
Shore erosion	22
Lack of handicap access sites	20
Lack of enforcement of boating rules and regulations	20
Not enough pamphlets, brochures, or maps describing public water access sites	19
Too much alcohol use by boat operators	19
Boat noise	18
Condition of parking lots at public water access sites	16
Pollution caused by outboard motors	15
Maintenance of boating facilities at public water access sites	15
Conflicts with water skiers	12
Conflicts with anglers	8
Too many public water access sites	6

Source: WDNR and SEWRPC

Table 2.21
Active Boat Counts and Carrying Capacity Assessment: 2023 - 2024

									Use Exceeded?		
Survey Date	Day of the Week	Power Boats	Sailboats	Personal Watercraft	Fishing Boats	Paddling Boats	Other[a]	Total Boats	Warren and Rea (1989)	Four Township (2001)	WALROS (2011)
6/12/2023	Monday	9	23		13		5	50	No	No	No
7/1/2023	Saturday	68		7	21	7	1	104	No	No	No
7/4/2023	Tuesday	194	1	6	20	7		228	No	No	No
7/19/2023	Wednesday	94	8	21	7	10	2	142	No	No	No
8/11/2023	Friday	68	3	5	9	3		88	No	No	No
8/15/2023	Tuesday	16	1	0	10	2		29	No	No	No
8/19/2023	Saturday	123	78	4	40	6		251	No	No	No
6/10/2024	Monday	5	14	1	14	1	1	36	No	No	No
7/4/2024	Thursday	184	1	13	17	7		222	No	No	No
7/6/2024	Saturday	93			18	3		114	No	No	No
7/17/2024	Wednesday	24	20	1	12			57	No	No	No
7/19/2024	Friday	68	36	3	20	3		130	No	No	No
8/14/2024	Wednesday	89	7	3	7	2	3	111	No	No	No
8/14/2024	Wednesday	183	2	6	10	5		206	No	No	No
8/16/2024	Friday	31		2	40	2		75	No	No	No
8/18/2024	Sunday	98	3	6	10	4	2	123	No	No	No

[a]"Other" boats included tour boats and pier barges.

Source: Geneva Lake Conservancy and SEWRPC

Table 2.22
Questions and Response Rate for the 2023 Geneva Lake User Survey

Question	Number of Responses	Number of Skips
Demographics		
What is your age?	276	0
In which municipality is your property located?	275	1
You are receiving this survey because you have residential property within the Geneva Lake watershed. How far is your property from Geneva Lake? If you own more than one property within the Geneva Lake watershed, please reflect on the property you have owned the longest.	276	0
What best describes how you use your property?	275	1
How long have you lived in the Geneva Lake area?	273	3
On a scale of 1 (most important) to 5 (least important). Please rank the importance of various portions of Geneva Lake to your use and enjoyment of the Lake.	247	29
Select any of the following activities that you participate in on Geneva Lake:	249	27
Overall, how important is Geneva Lake to your choice to own property in the Geneva Lake area?	249	27
Geneva Lake Use and Perceptions		
The following lists factors that are commonly thought to negatively affect Wisconsin inland lakes. How much do you believe each of the following factors is affecting Geneva Lake?	248	28
How frequently do you recreate on Geneva Lake's surface or shoreline during summer (June - August)?	249	27
How frequently do you recreate on Geneva Lake's surface or shoreline during the fall, winter and spring (September - May)?	249	27
How often, if at all, do you fish on Geneva Lake during the open water season (May - November)?	249	27
How would you rate the following aspects of your fishing experience?	248	28
Select all the species that you fish for on Geneva Lake:	234	42
How much, if at all, do piers and/or mooring buoys interfere with your fishing?	242	34
Overall, how concerned do you feel about water quality on Geneva Lake?	246	30
Do you agree or disagree with each of the following statements regarding Geneva Lake's water quality?	250	26
How much, if at all, does Geneva Lake's aquatic plant growth impact your recreation?	249	27
How often do you use a motorboat on Geneva Lake?	244	32
How much, if at all, does boat traffic on Geneva Lake during summer weekdays impact your boating?	243	33
How much, if at all, does boat traffic on Geneva Lake during summer weekends and holidays impact your boating?	243	33
Which statement best describes your experience with boaters on Geneva Lake?	242	34
Occasionally different user-groups want to use the same space for conflicting recreational goals. What portions of the Lake, if any, do you feel such friction occurs between lake users?	230	46
How do commercial piers, boat liveries, and marinas affect your use and enjoyment of the Lake (Choose one)?	228	48
What level of concern do you have about the impact of the following boating conditions, behaviors, or actions on your use and enjoyment of the Lake? Please respond to each question identifying your level of concern.	243	33
Which of the following describes your opinion of current public boating launch access on Geneva Lake?	241	35
Property Management		
If you own lakeshore property or property next to a stream, which of the following statements best describes your property	225	51
Do you apply fertilizer, insecticides, and/or herbicides to your property? (select all that apply for you)	218	58

From the list below, please indicate any beneficial management practices that you currently do on your property:	175	101
Which of the following common barriers, if any, keep you from implementing or adding to your property the beneficial management practices described in the previous question.	172	104
How often do you have your septic system or holding tank pumped?	217	59
Please select the severity of soil erosion observed on your property:	220	56
Are you aware of these available grants and programs available to implement practices that protect the Lake (select all that apply)?	220	56
How do you obtain information regarding Geneva Lake? (Identify top three options)	232	44
Geneva Lake Management		
How satisfied are you with the current management of Geneva Lake?	219	57
Please select how much you support the following aquatic plant management options:	216	60
The following items are management goals or actions that may require additional funding to accomplish, and we'd like to understand what items are a priority for the Geneva Lake community. Please select up to three management issues that you think would bring the most value to the Lake.	220	56
Would you be willing to contribute funds, or additional funds beyond what you may currently contribute in order to support additional lake and watershed management? This is not regarded as a commitment, but rather will be used to gauge potential investment from the community.	217	59
If additional funds need be raised to accomplish lake management goals, how would you prefer those funds be raised (select all that apply)?	215	61
OPTIONAL: Share your name and contact information below if you would like t be added to the mailing list for future information about the Geneva Lake Management Plan.	84	192

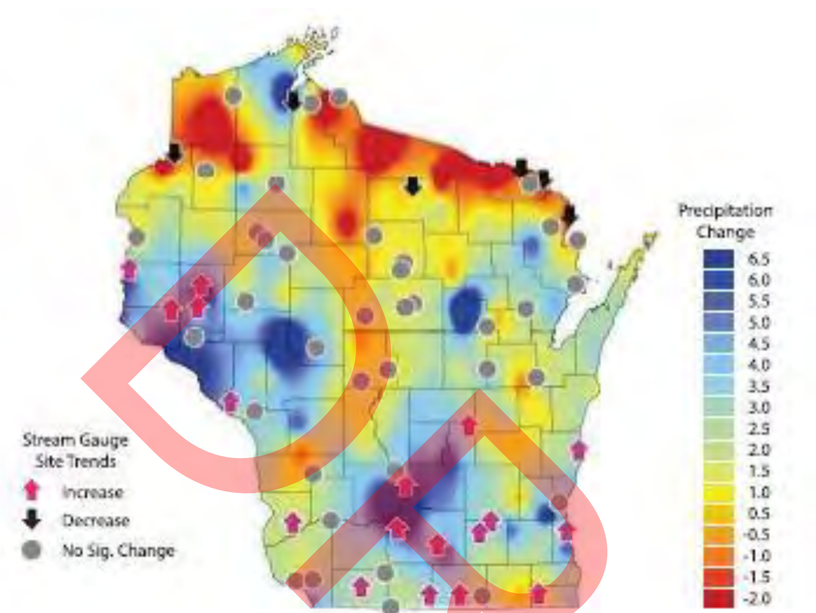
Source: GLC and SEWRPC

SEWRPC Community Assistance Planning Report Number 60 (3rd Edition)

A LAKE MANAGEMENT PLAN FOR GENEVA LAKE
WALWORTH COUNTY, WISCONSIN

Appendix

Figure 2.1
River Baseflow and Precipitation Change in Wisconsin: 1960-2006



From 1950-2006, Wisconsin as a whole became wetter, with an increase in annual precipitation of 3.1 inches. This increase has primarily occurred in southern and western Wisconsin, while northern Wisconsin experienced some drying. Concomitantly, stream baseflow increased in wetter areas.

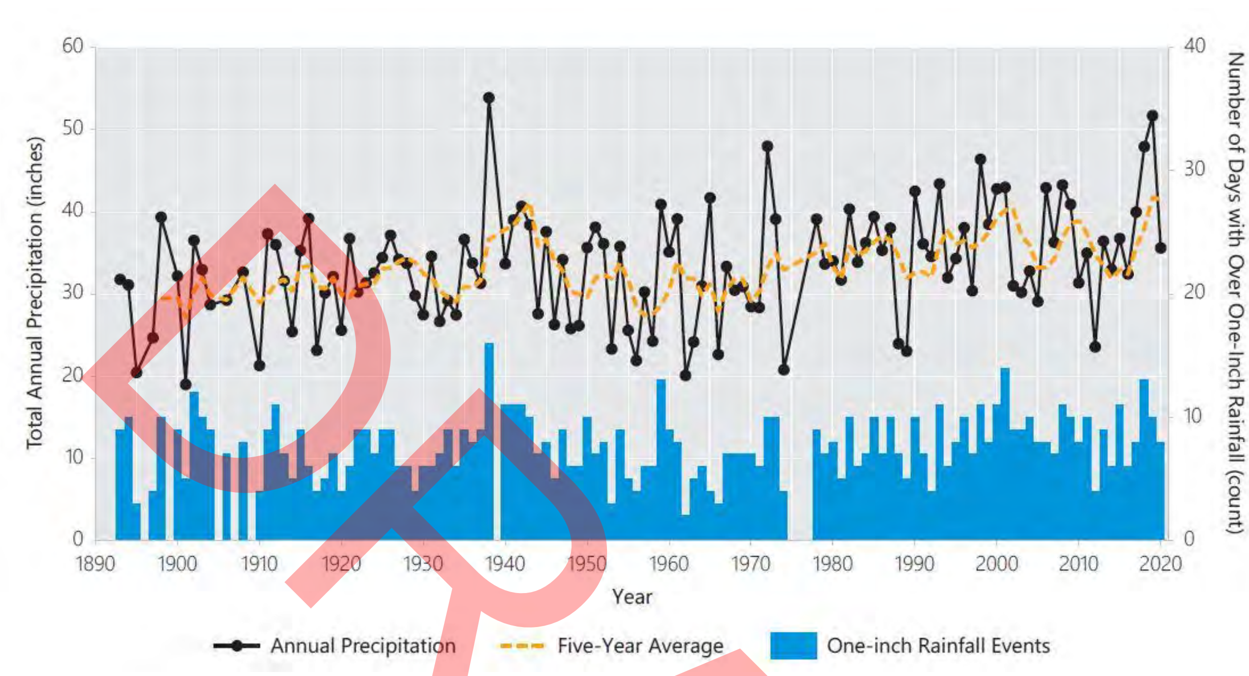
Source: Water Resources Working Group of the Wisconsin Initiative on Climate Change Impacts and SEWRPC

Figure 2.2
Human Influence on the Hydrologic Cycle

This schematic shows how human processes associated with land use development affect how water moves through the hydrologic cycle. Water returns to the atmosphere through evaporation (process by which water is changed from liquid to vapor), sublimation (direct evaporation by snow and ice), and transpiration (process by which plants give off water vapor through their leaves).

Source: Water Resources Working Group of the Wisconsin Initiative on Climate Change Impacts and SEWRPC

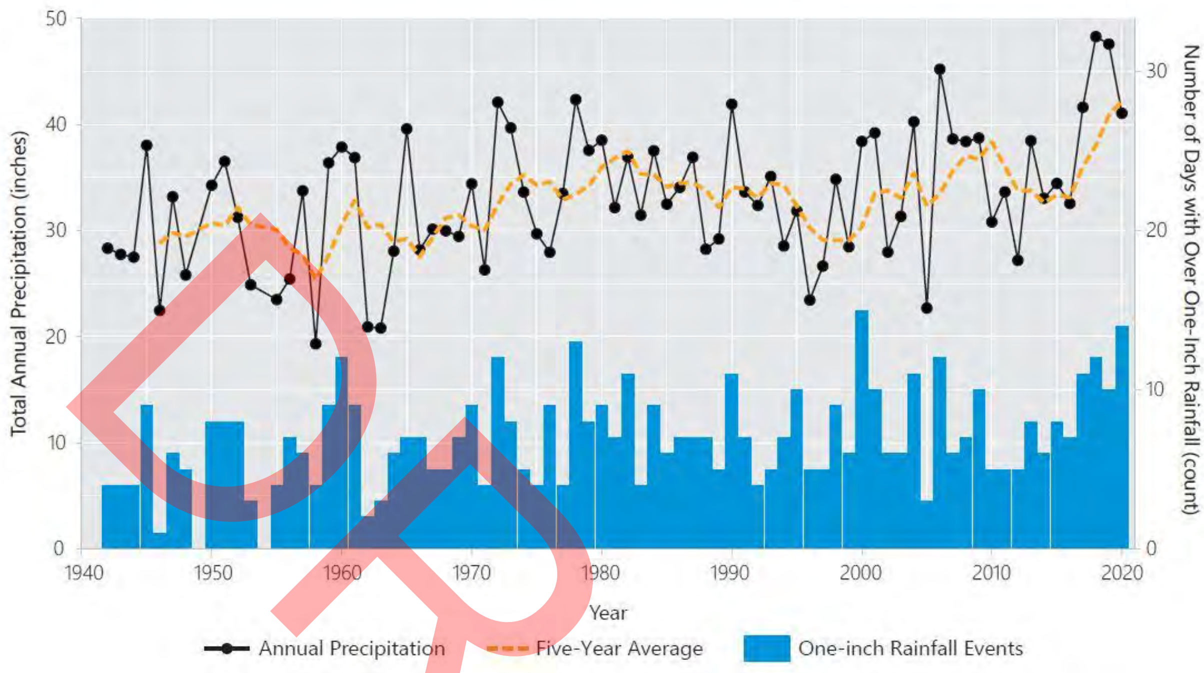
Figure 2.3
Beloit Total Annual Precipitation and One-Inch Rainfall Events: 1942-2020



Note: Daily weather data downloaded from USC00470696 in Beloit, Wisconsin. 1896, 1899, 1905, 1907, 1909, 1939, 1975, 1976, and 1997 omitted due to insufficient data.

Source: NOAA and SEWRPC

Figure 2.4
Union Grove Total Annual Precipitation and One-Inch Rainfall Events: 1942-2020



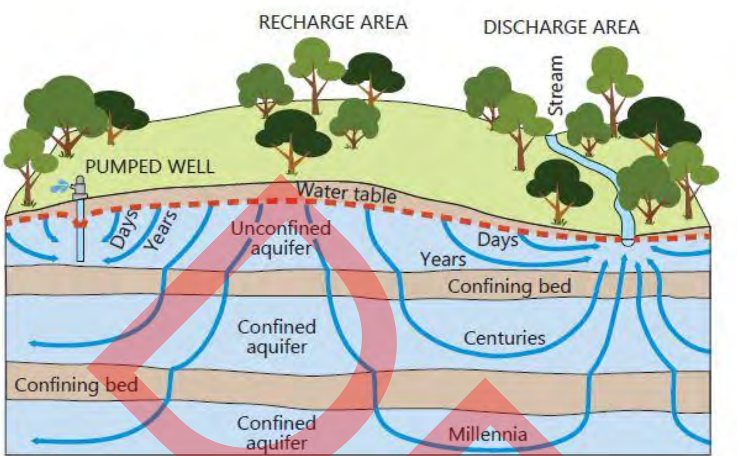
Note: Daily weather data downloaded from USC00478723 in Union Grove, Wisconsin. 1954 omitted due to insufficient data

Source: NOAA and SEWRPC

Figure 2.5
Headcutting Erosion in Geneva Lake Watershed

Source: SEWRPC

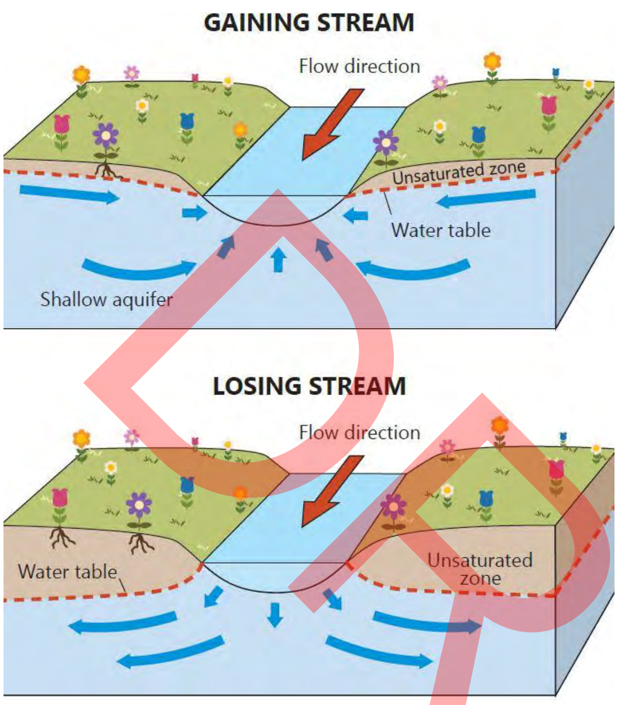
Figure 2.6
Regional vs. Local Groundwater Flow Paths



Note: Groundwater flows from recharge areas at the water table to discharge locations at the stream and well. The residence time of groundwater can range from days to centuries to millennia.

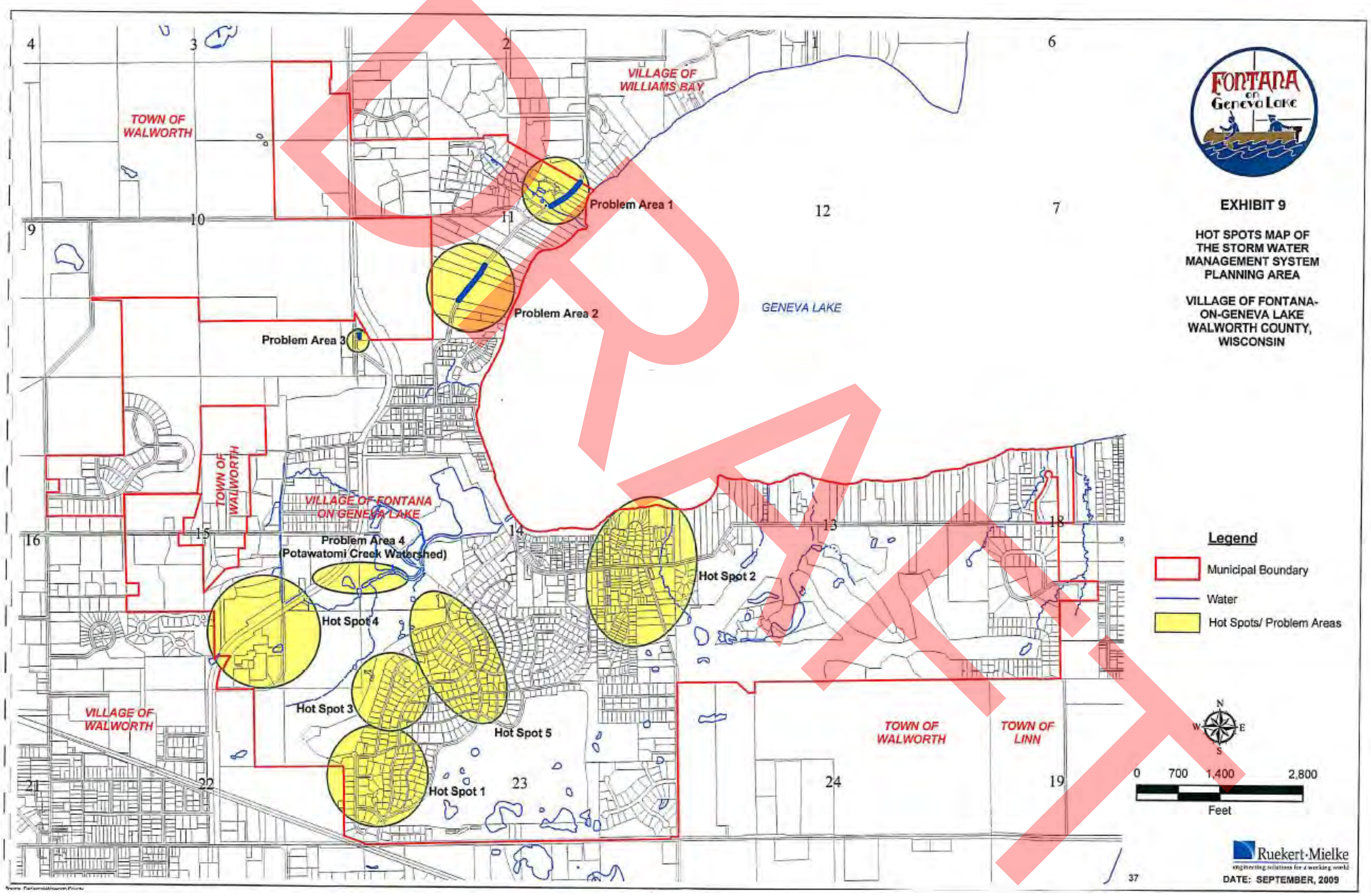
Source: U.S. Geological Survey and SEWRPC

Figure 2.7
Surface Water-Groundwater Interactions

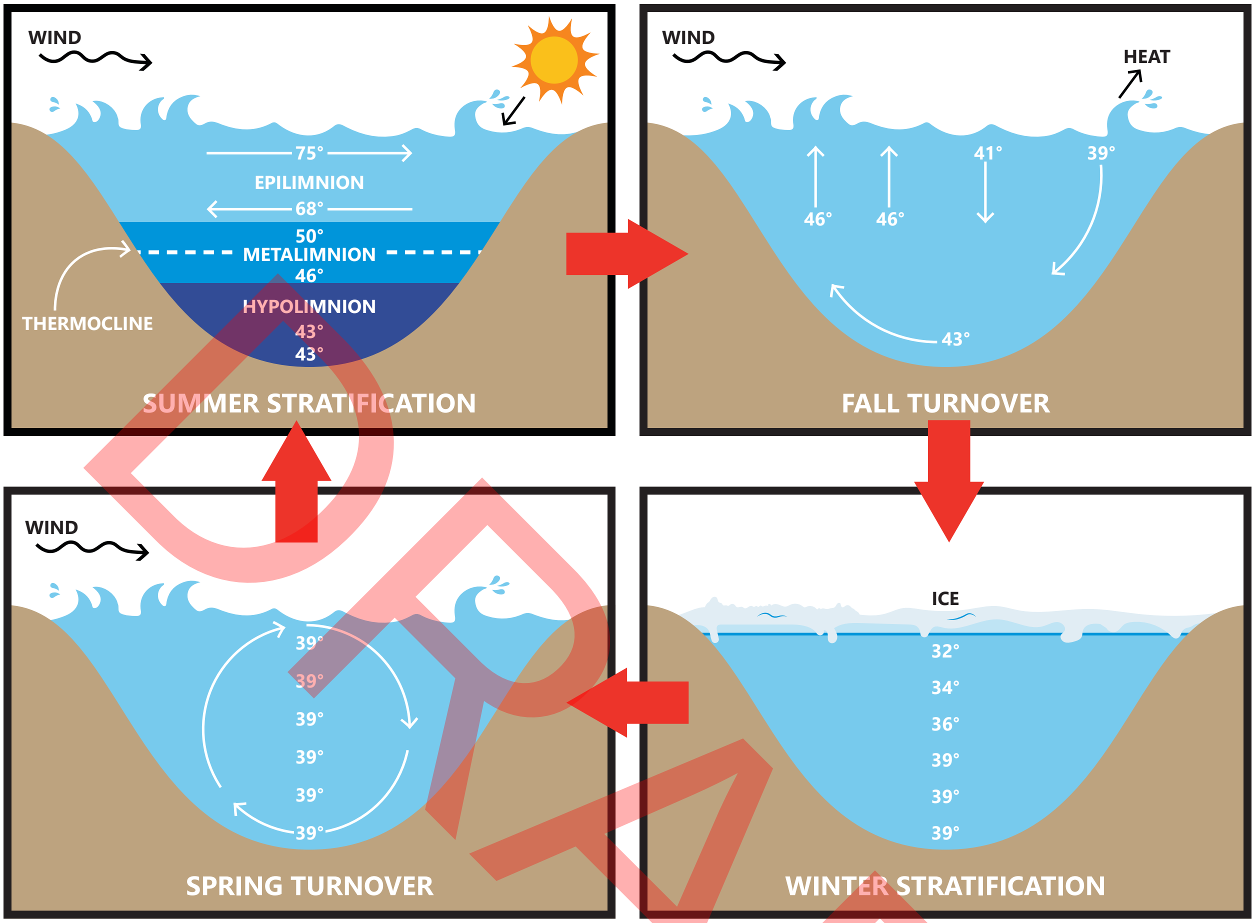


Source: Modified from T.C. Winter, J.W. Harvey, O.L. Franke, and W.M. Alley, Groundwater and Surface Water: A Single Resource, *U.S. Geological Survey Circular 1139, p. 9, 1998, and SEWRPC*

Figure 2.8
Village of Fontana-On-Geneva Lake Map of Stormwater Management System Planning Area



Source: Rukert-Mielke and Village of Fontana-on-Geneva-Lake



Source: Modified from B. Shaw, C. Mechenich, and L. Klessig, Understanding Lake Data, *University of Wisconsin-Extension, p. 3, 2004 and SEWRPC*

OLIGOTROPHIC
- Clear water, low productivity
- Very desirable fishery of large game fish

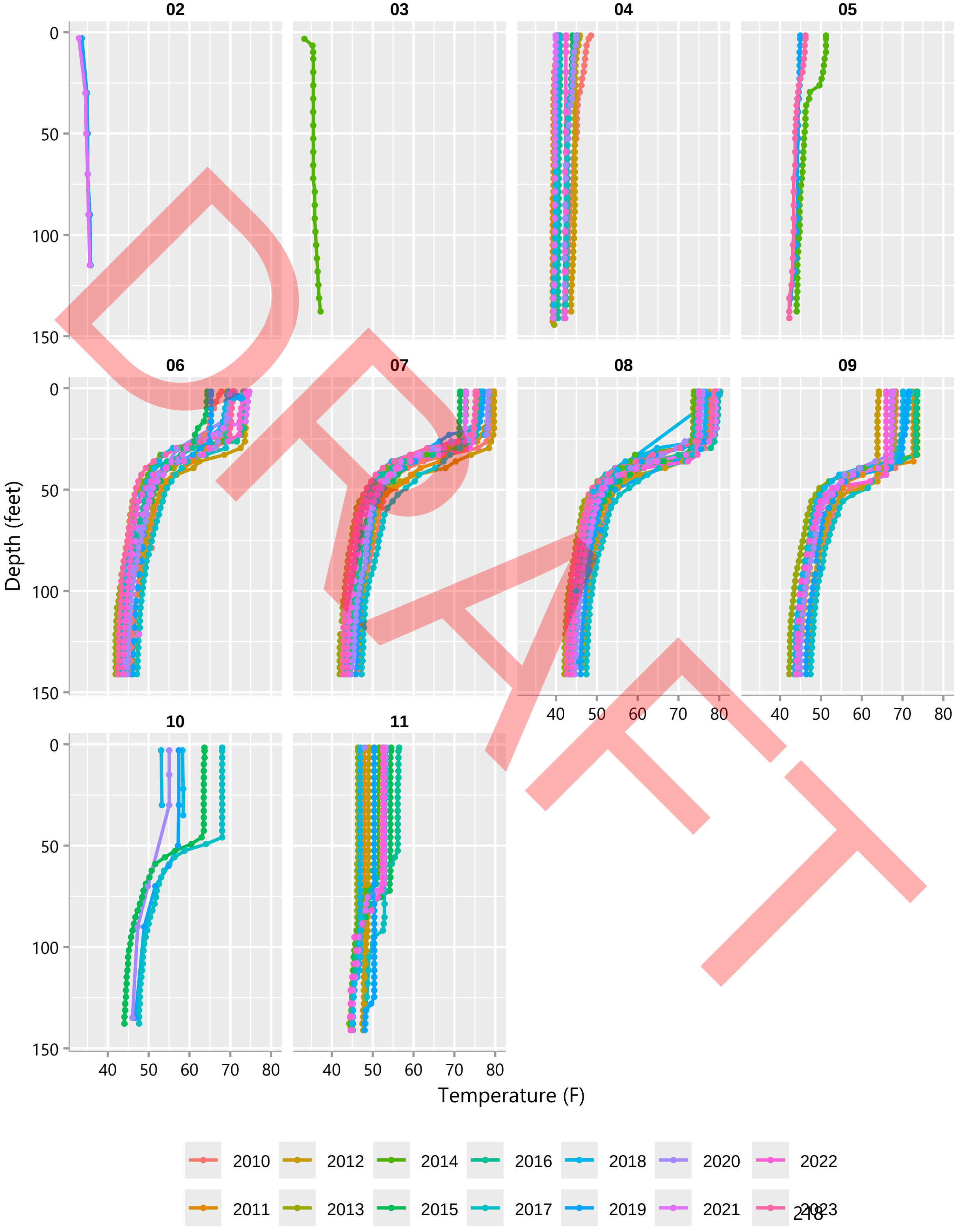
MESOTROPHIC
- Increased production
- Accumulated organic matter
- Occasional algal bloom
- Good fishery

EUTROPHIC
- Very productive
- May experience oxygen depletion
- Rough fish common

Source: Modified from B. Shaw, C. Mechenich, and L. Klessig, Understanding Lake Data, *University of Wisconsin-Extension, p. 5, 2004 and SEWRPC*

Figure 2.11

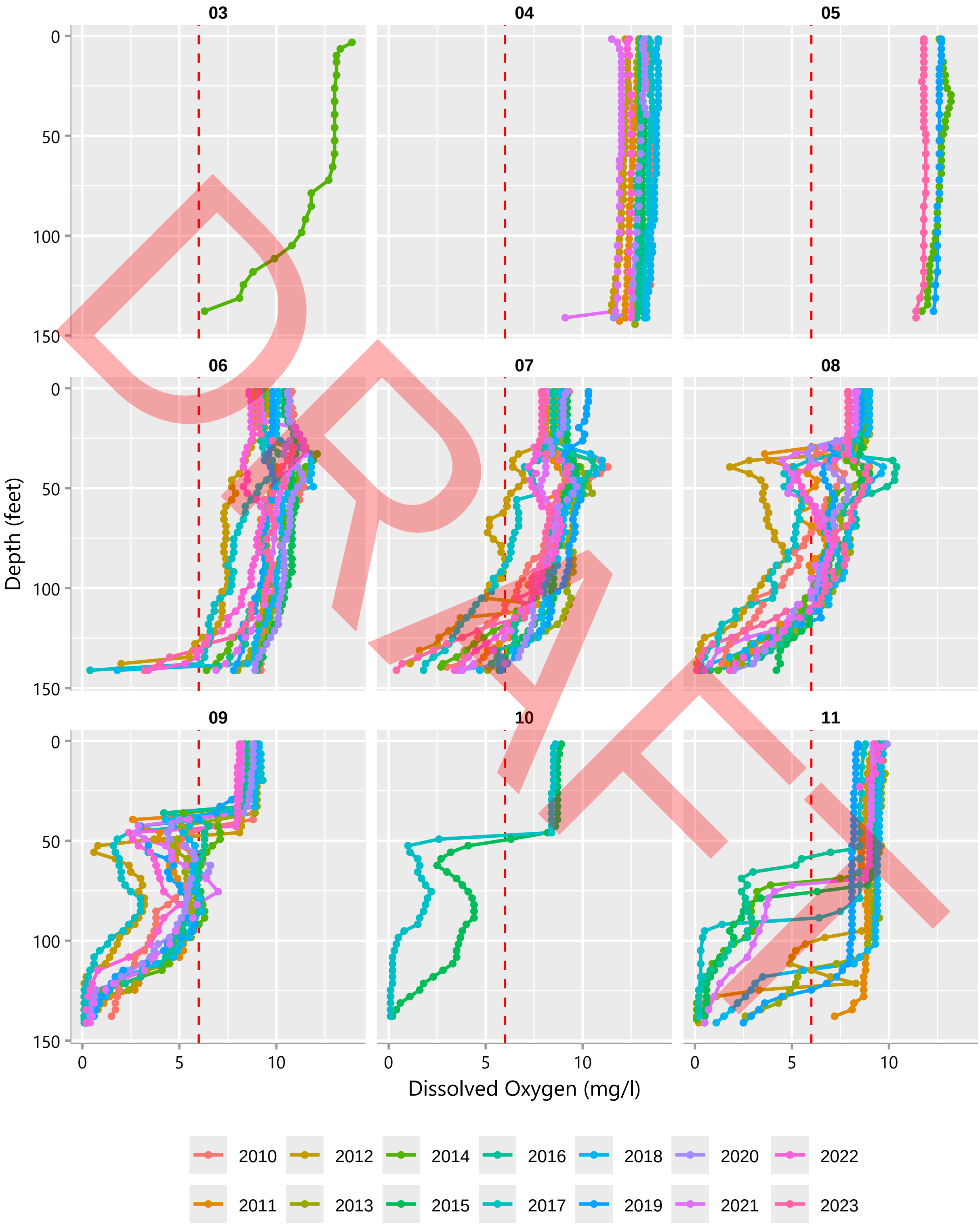
Geneva Lake Water Temperature Profiles by Month: 2010 - 2023



Source: GLEA, USGS, WDNR, and SEWRPC

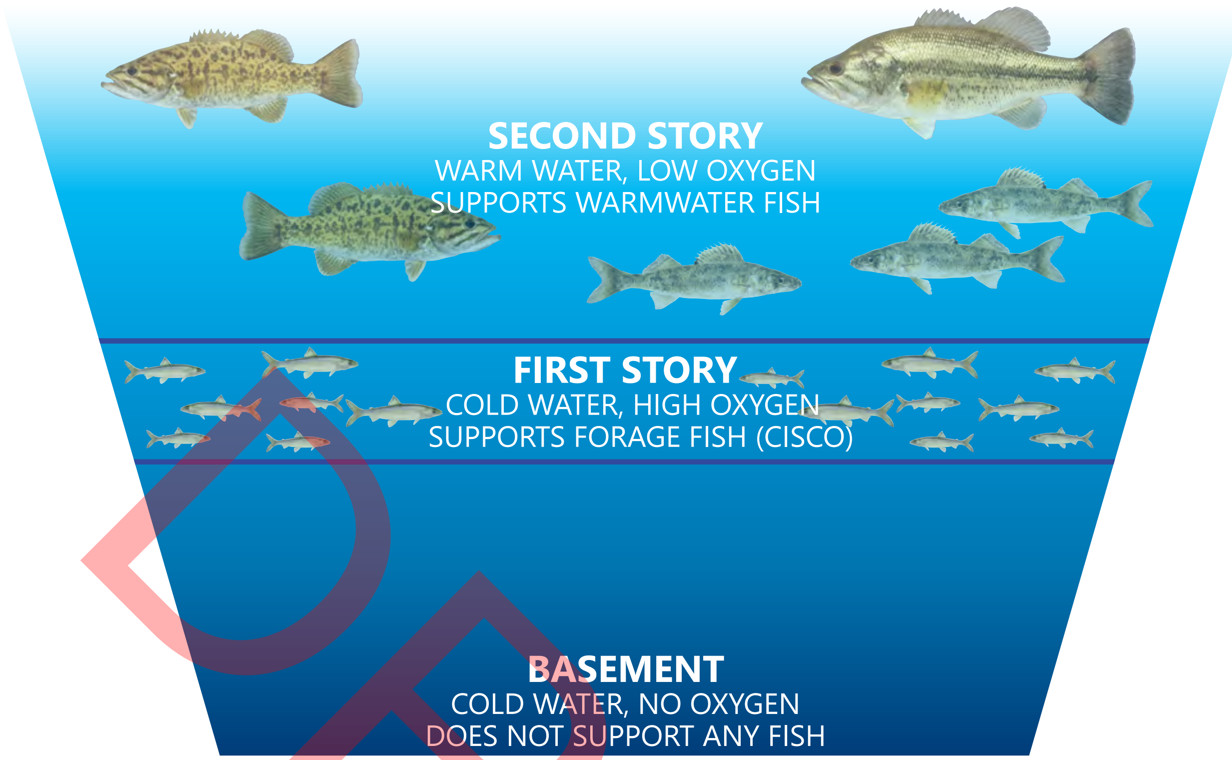
Figure 2.12

Geneva Lake Dissolved Oxygen Profiles by Month: 2010 - 2023



Note: Red dashed line indicates 5 mg/l; concentrations below this can be stressful to aquatic life.

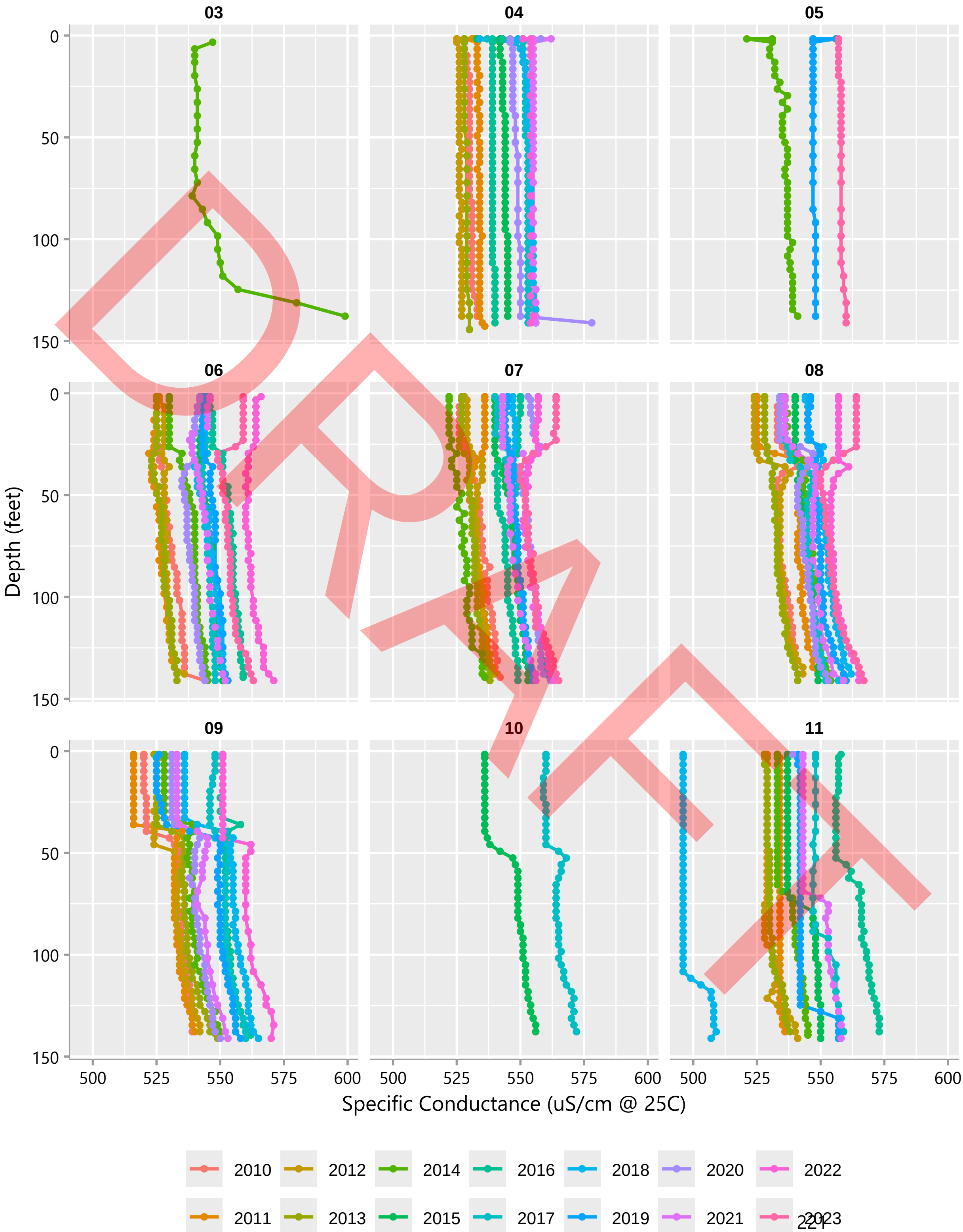
Source: GLEA, USGS, WDNR, and SEWRPC



Note: This graphic illustrates a functioning "two-story" fishery, where a band of deep, cold, and oxygenated water supports a population of cisco (*Coregonus artedi*). Cisco are a forage fish that support more abundant populations of fish eating gamefish, such as walleye. Reduced dissolved oxygen concentrations in deep water, caused by poor water quality, can shrink the habitat available to cisco, eventually causing total loss of the cisco population within a lake.

Figure 2.14

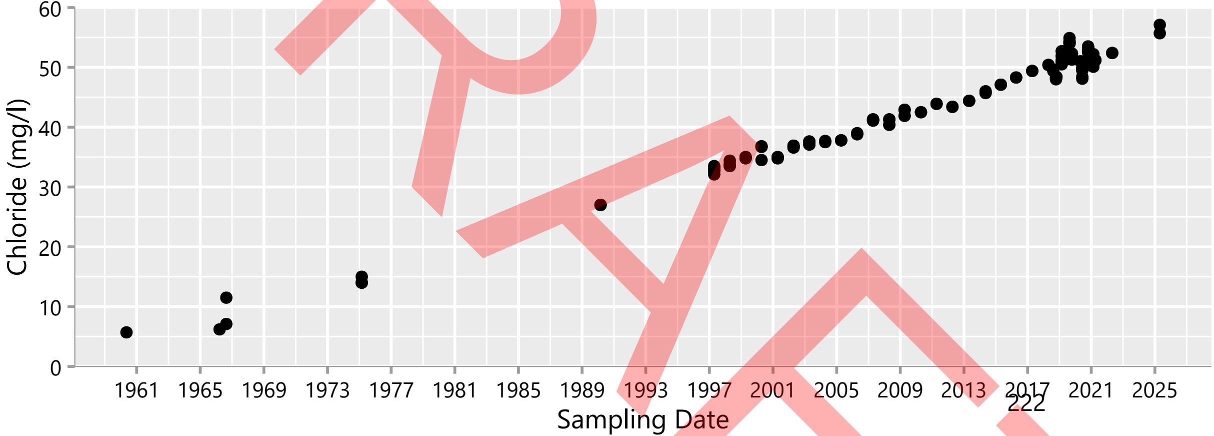
Geneva Lake Specific Conductance Profiles by Month: 2010 - 2023



Source: GLEA, USGS, WDNR, and SEWRPC

Figure 2.15

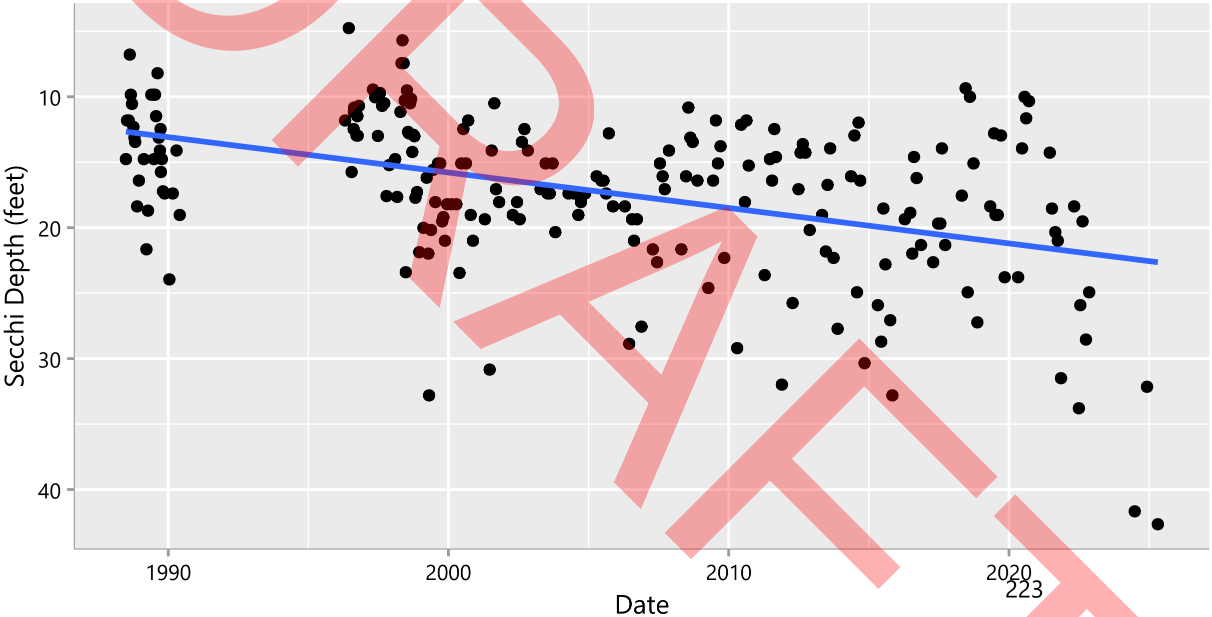
Chloride Concentrations in Geneva Lake: 1960 - 2025



Source: GLEA, USGS, WDNR, and SEWRPC

Figure 2.16

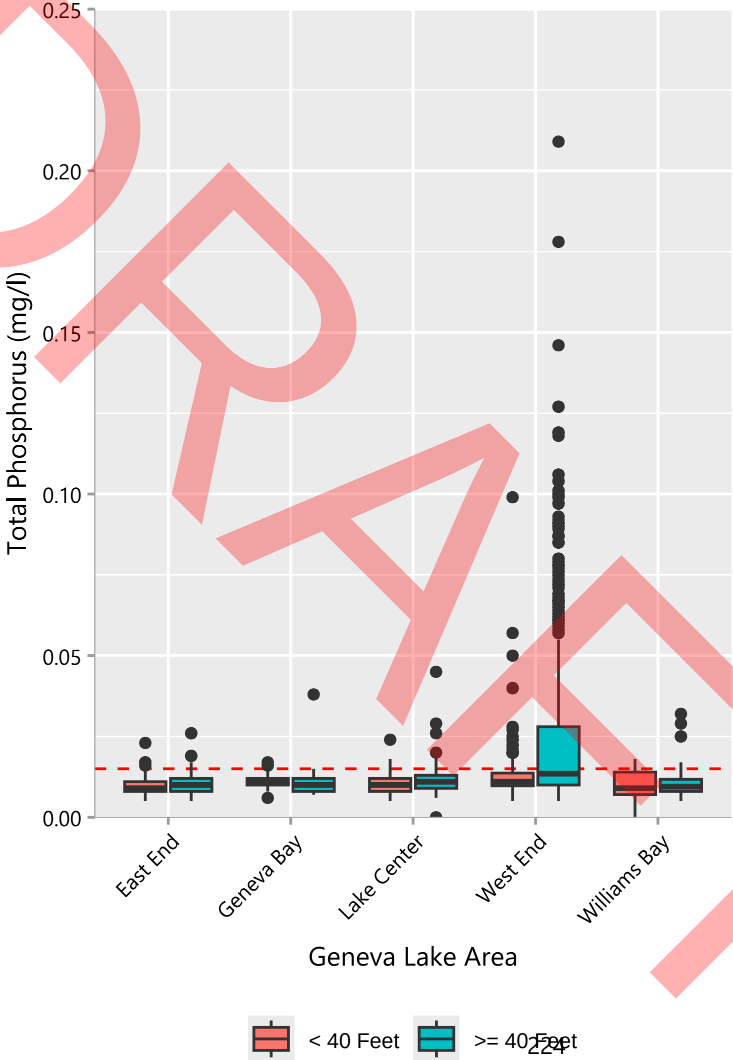
Daily Mean Secchi Depth in Geneva Lake: 1988 - 2025



Source: GLEA, USGS, WDNR, and SEWRPC

Figure 2.17

Total Phosphorus Concentrations by Lake Area and Depth: 1960 - 2025



Source: GLEA, USGS, WDNR, and SEWRPC

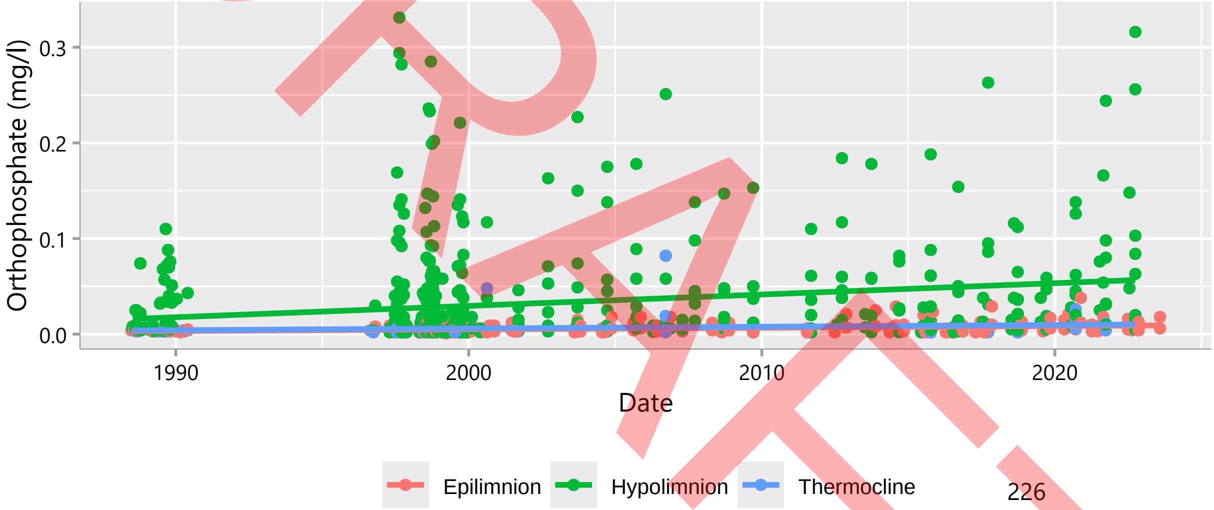
Figure 2.18

Trends in Summer Total Phosphorus Concentrations Over Time by Geneva Lake Depth

Source: GLEA, USGS, WDNR, and SEWRPC

Figure 2.19

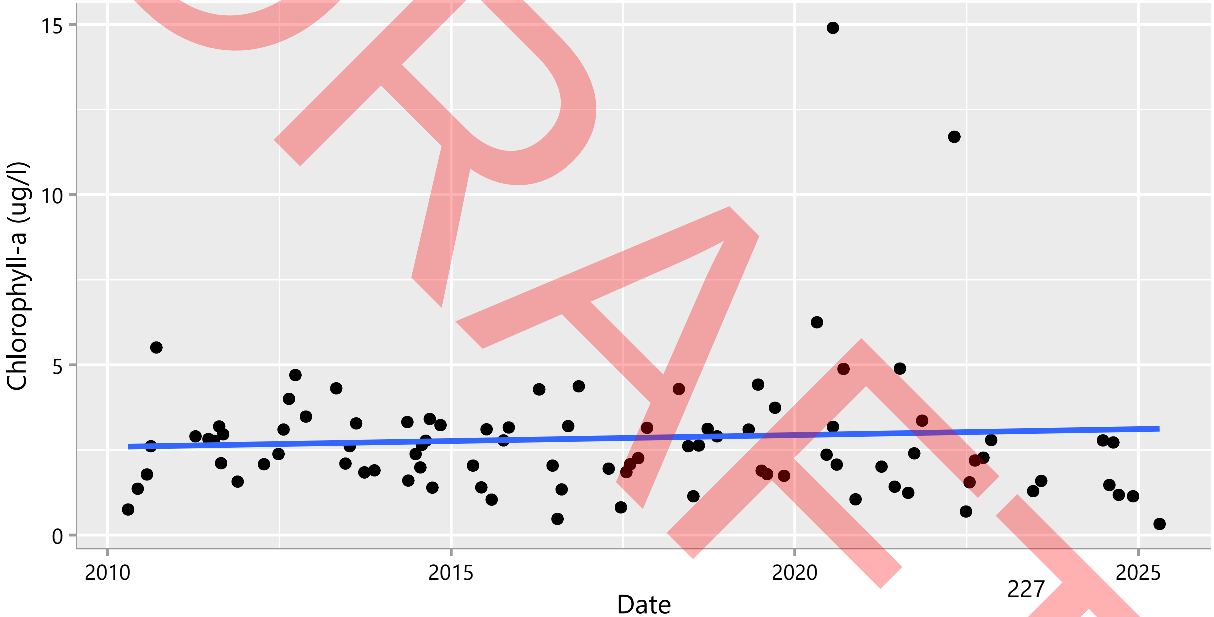
Orthophosphate Concentrations over Time in Geneva Lake



Source: GLEA, USGS, WDNR, and SEWRPC

Figure 2.20

Chlorophyll Concentrations Reported for Geneva Lake: 1988 - 2025



Source: GLEA, USGS, WDNR, and SEWRPC

Figure 2.TSI

Geneva Lake Triphic State Index: 1960 - 2025

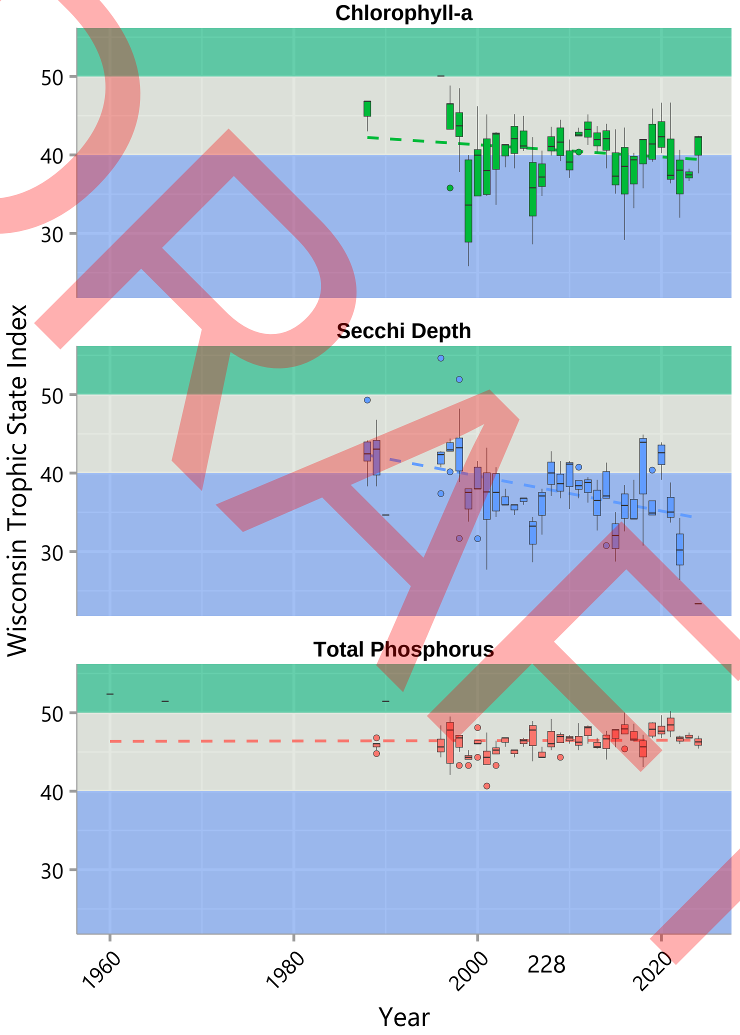


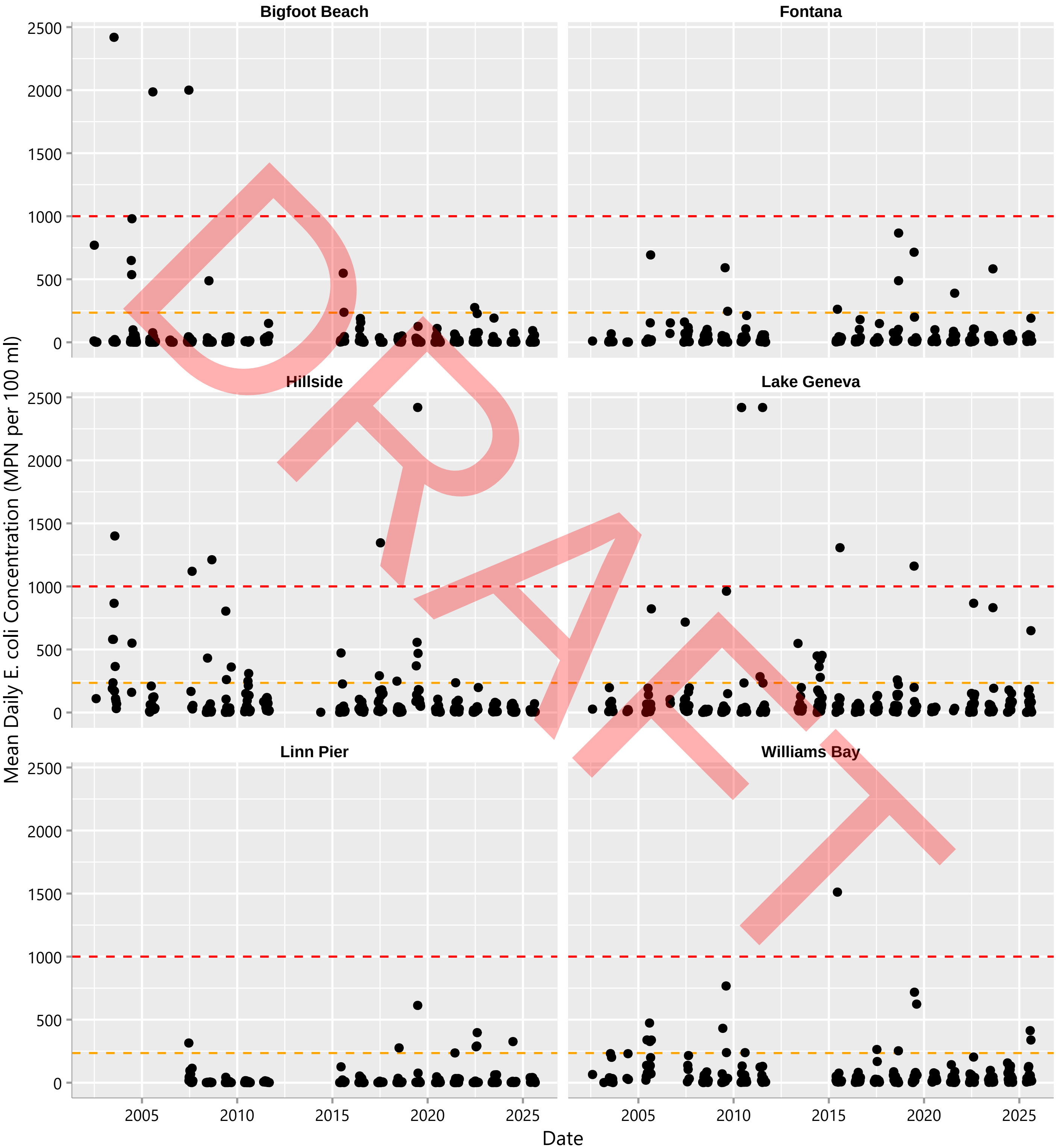
Figure 2.22

Total Nitrogen of Geneva Lake: 1975 - 2022

Source: GLEA, USGS, WDNR, and SEWRPC

Figure 2.23

Mean Daily E. coli Concentrations at Beach Monitoring Sites on Geneva Lake: 2002 - 2025



Note: The orange and red dashed lines indicate the beach advisory and closure concentrations of 235 and 1,000 MPN per 100 ml.

Source: GLEA, WDNR, and SEWRPC

Figure 2.24
Red-colored water observed in Bigfoot Creek - July 2024.

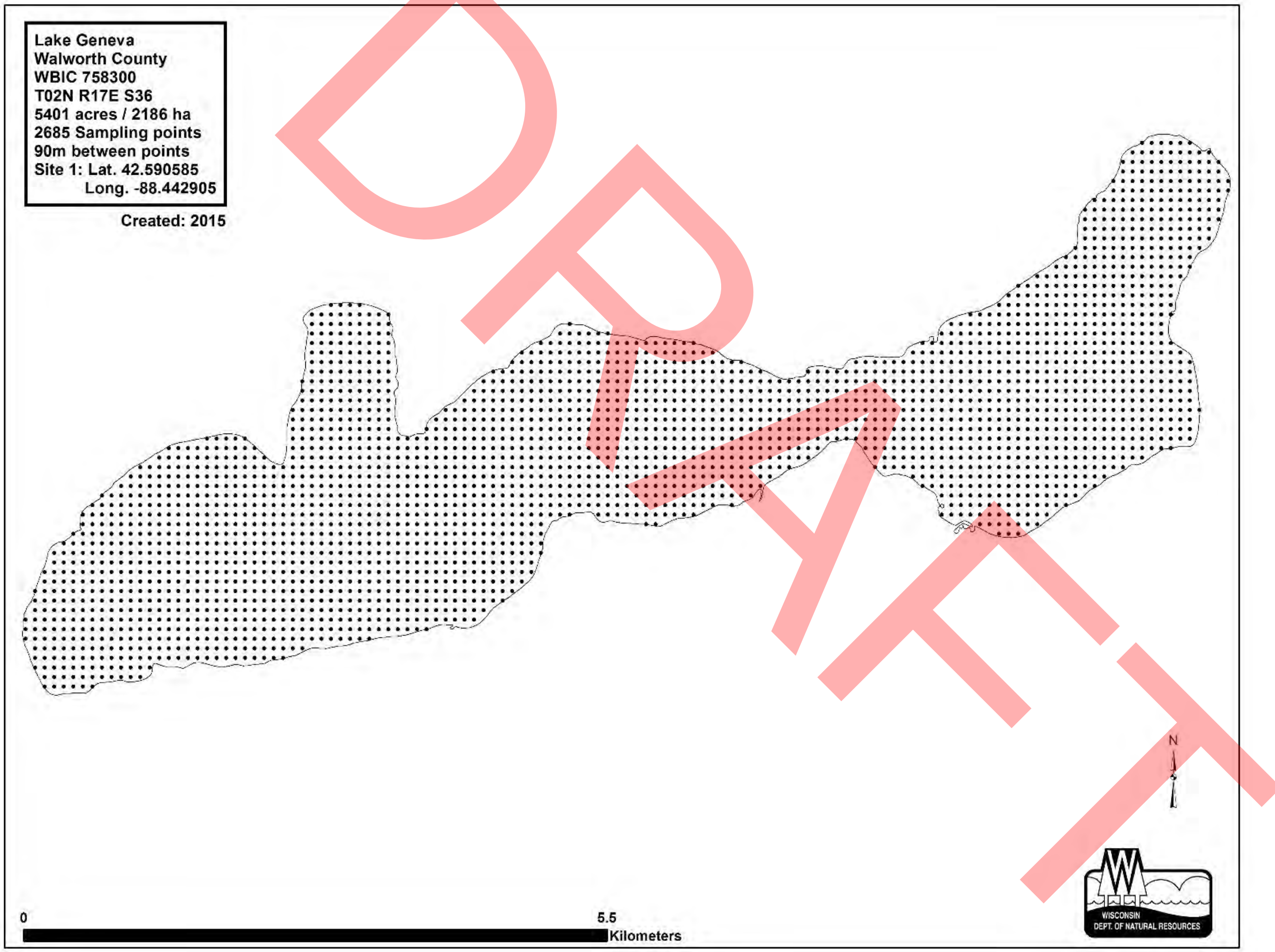
Figure 2.25
Assessment of Water Quality Parameters in Bigfoot Creek – July 2024

Source: SEWRPC

Figure 2.26
Assessment of Water Quality Parameters in Bigfoot Creek – August 2024

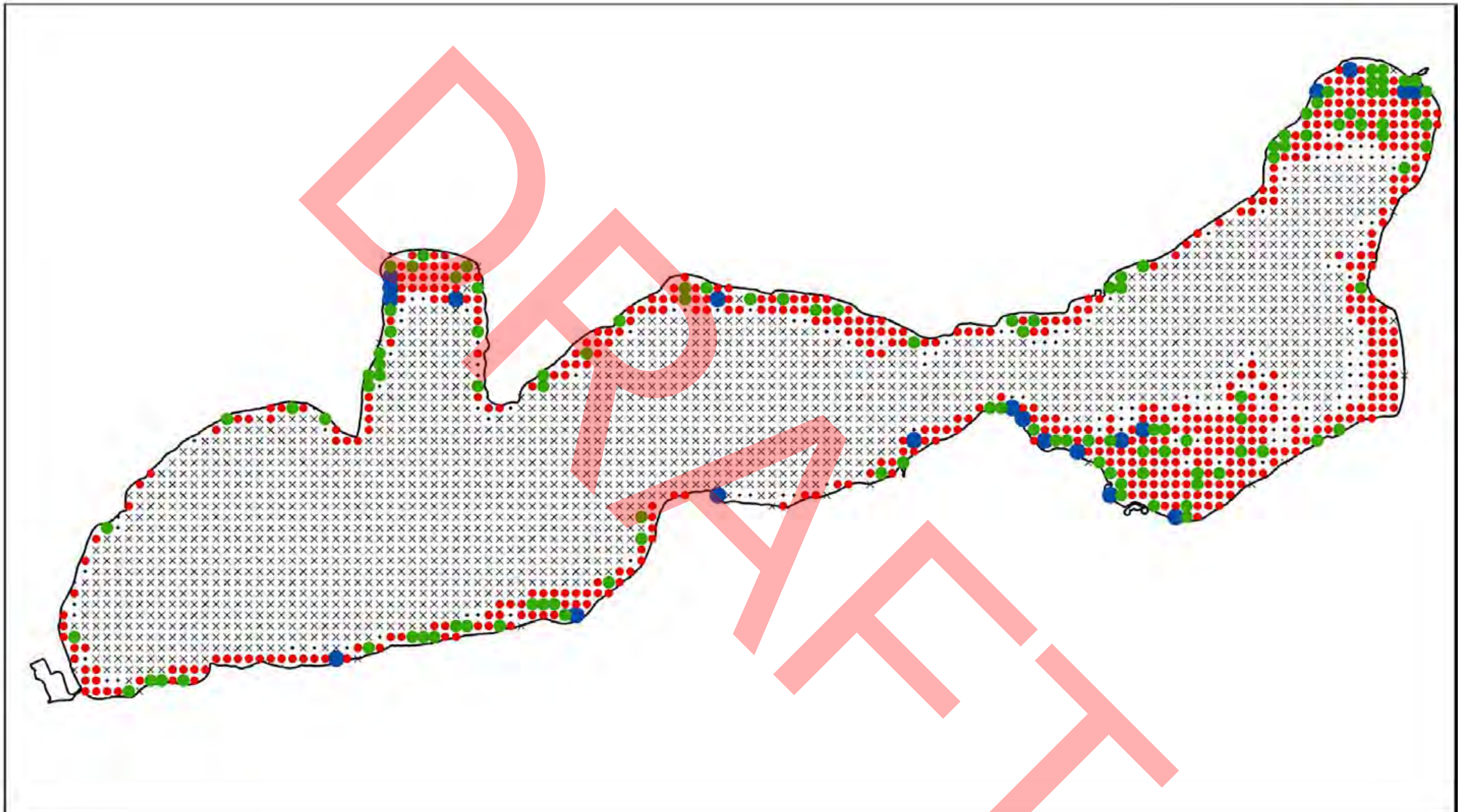
Note: Sites BF1 and BF4 correspond with July 2024 SEWRPC sampling sites BC1 and BC2, respectively.
Source: Geneva Lake Conservancy and SEWRPC

Figure 2.27
Point-Intercept Grid of Geneva Lake, Walworth County



Source: WDNR

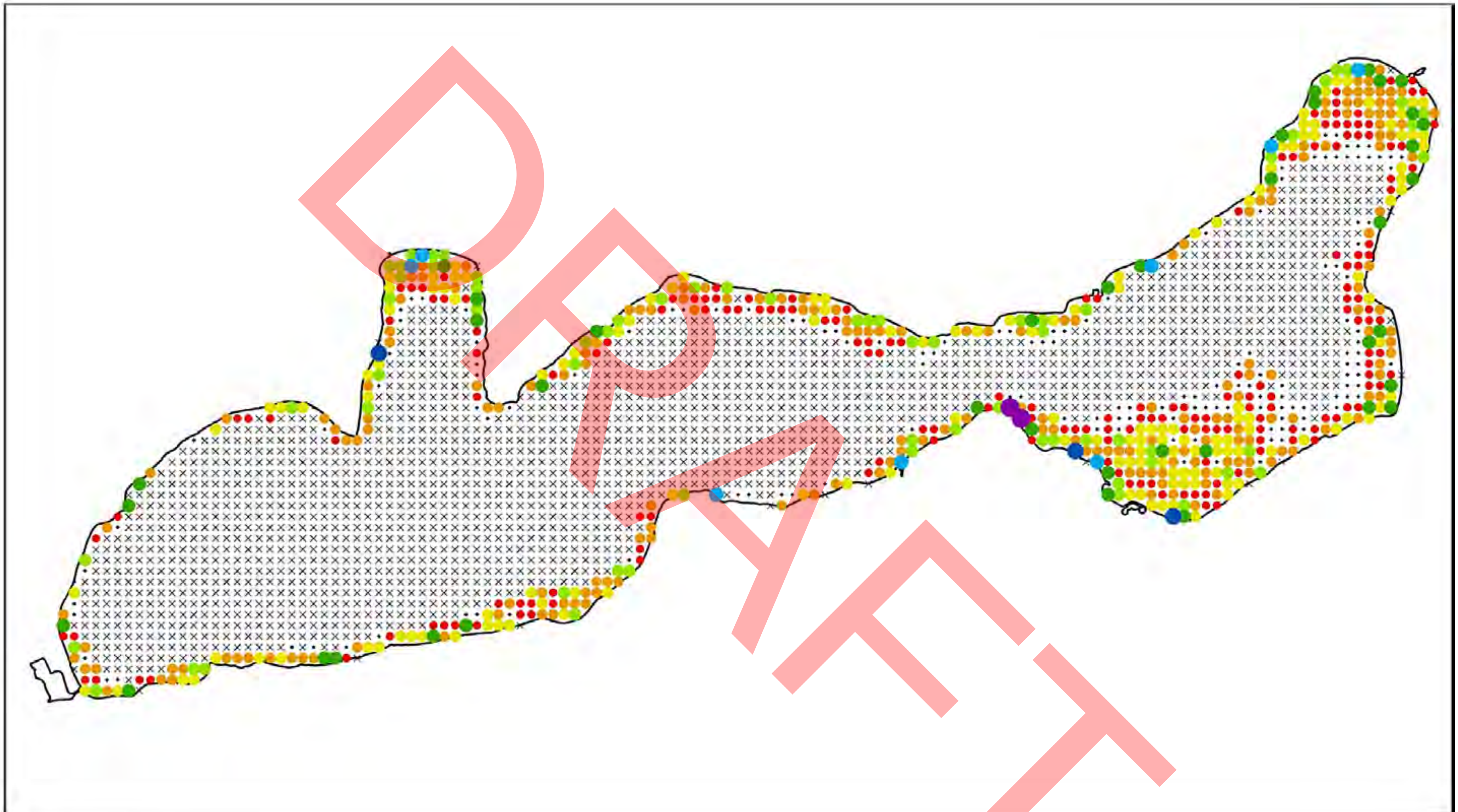
Figure 2.28
Total Rake Fullness in Geneva Lake: July 2024



NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.

Source: WDNR and SEWRPC

Figure.2.29
Species Richness in Geneva Lake: July 2024



NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.

Species Richness

Species_Ri

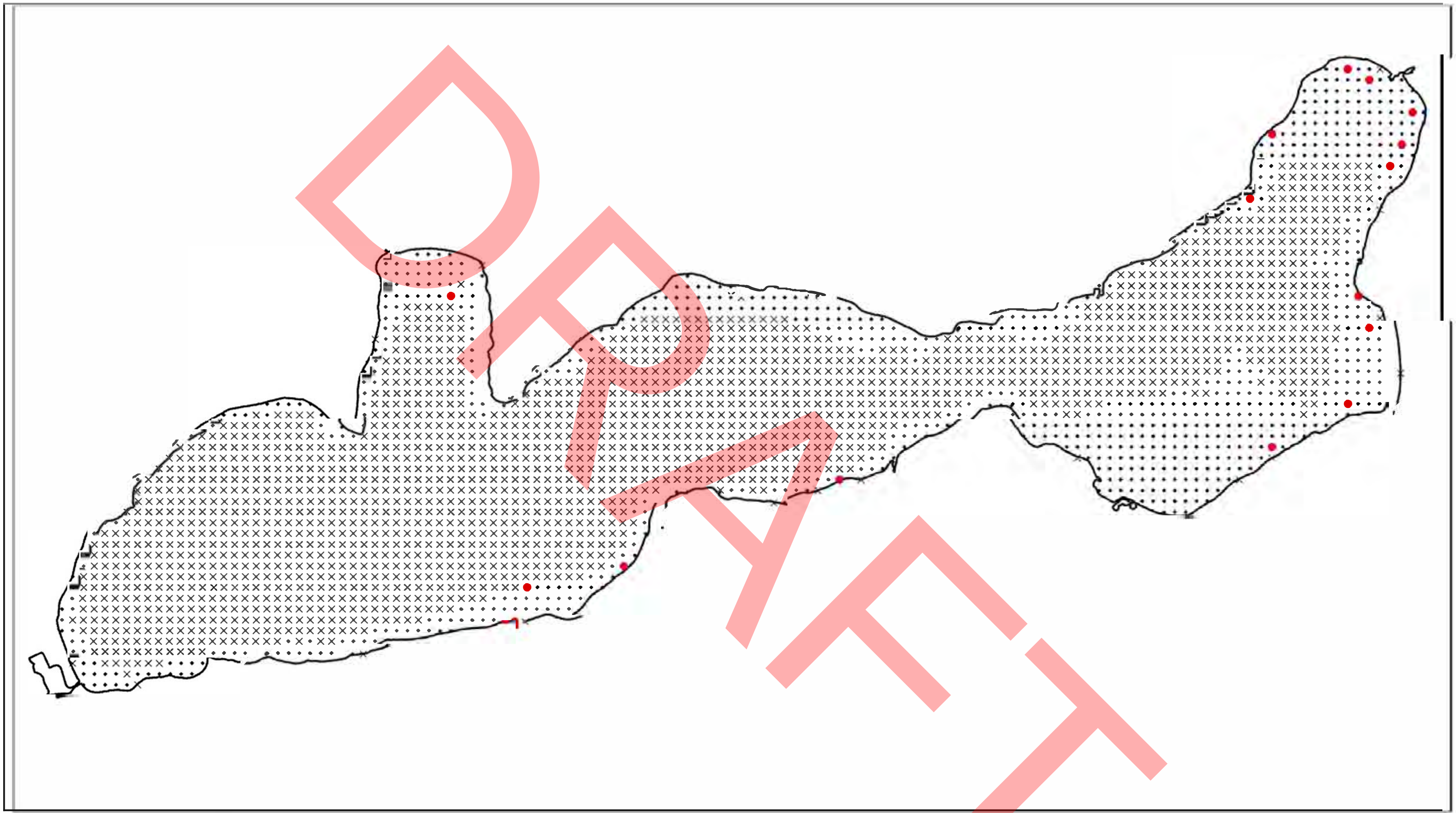
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8

GenevaLake_Shoreline

0 1,050 2,100 4,200 Feet

Source: WDNR and SEWRPC

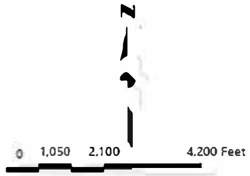
Figure 2.30
Sensitive Species Richness in Geneva Lake: July 2024



NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.

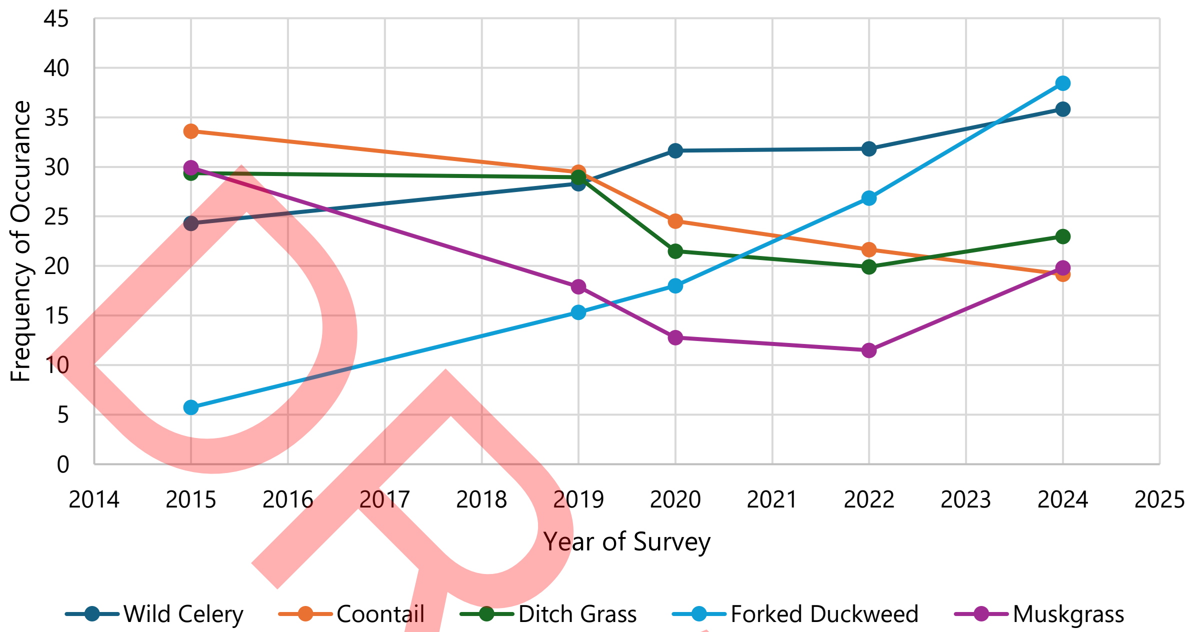
SENSITIVE SPECIES RICHNESS

● 1



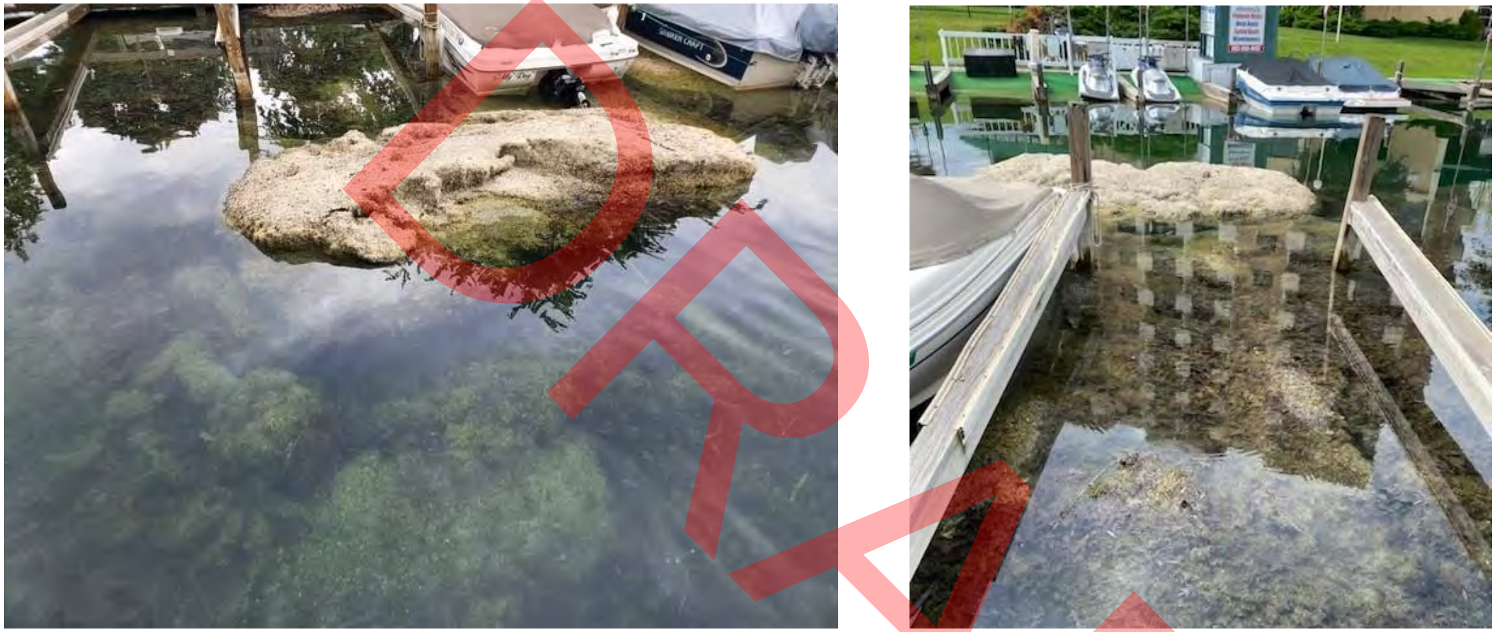
Source. WDNR and SEWRPC

Figure 2.31
Frequency of Occurrence of On-Average Most Common Native Aquatic Plants in Geneva Lake



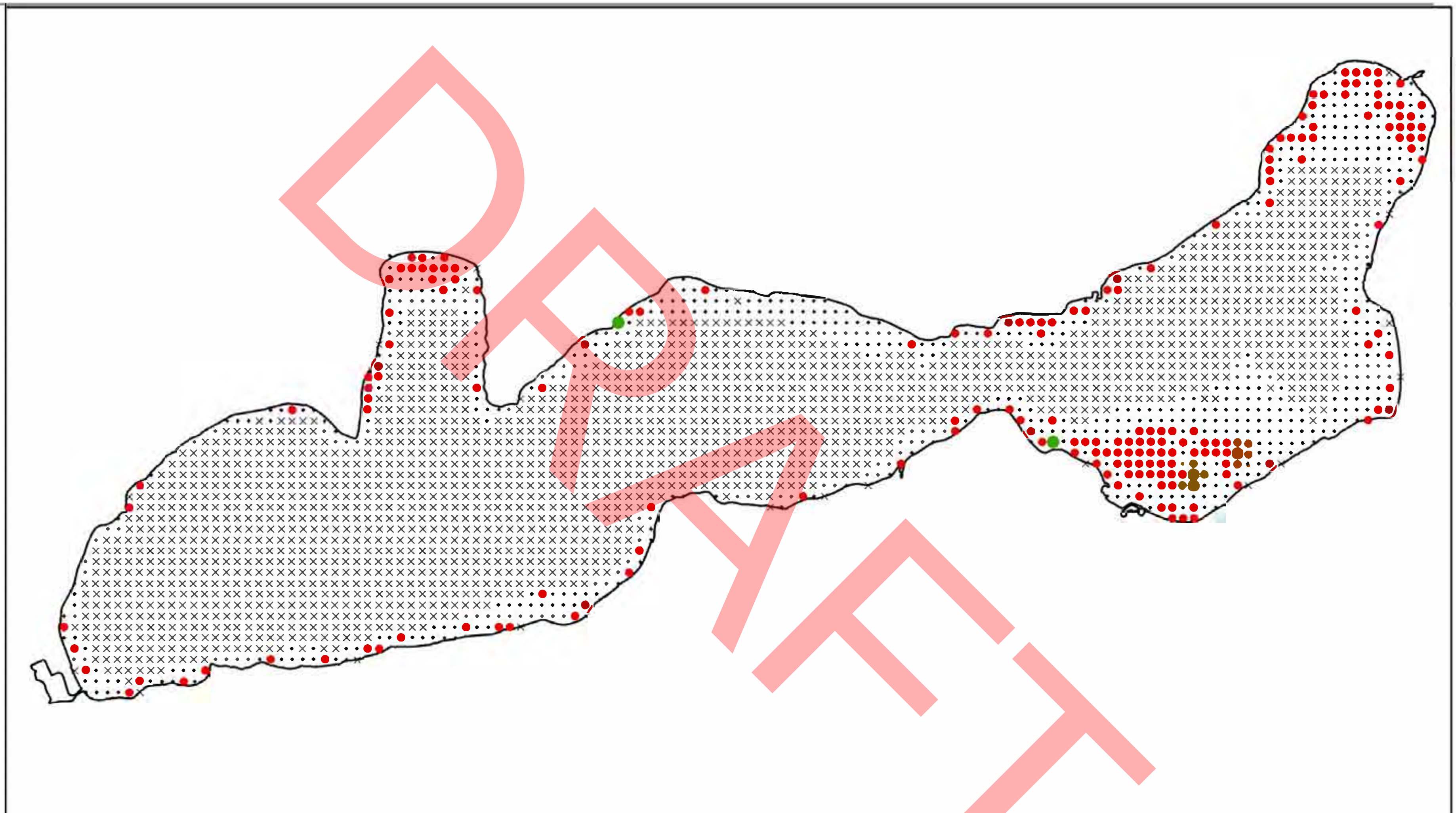
Source: SEWRPC

Figure 2.32
Accumulations of Forked Duckweed in Lake Geneva Harbor



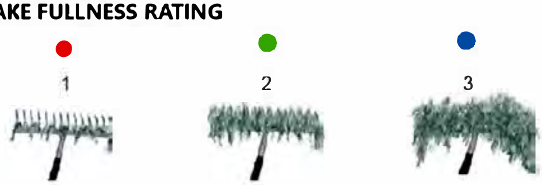
Source: GLEA

Figure 2.33
Eurasian Watermilfoil Total Rake Fullness in Geneva Lake: July 2024



NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.

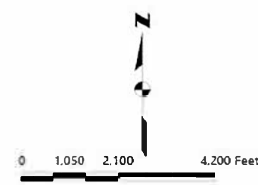
RAKE FULLNESS RATING



VISIBLE NEARBY

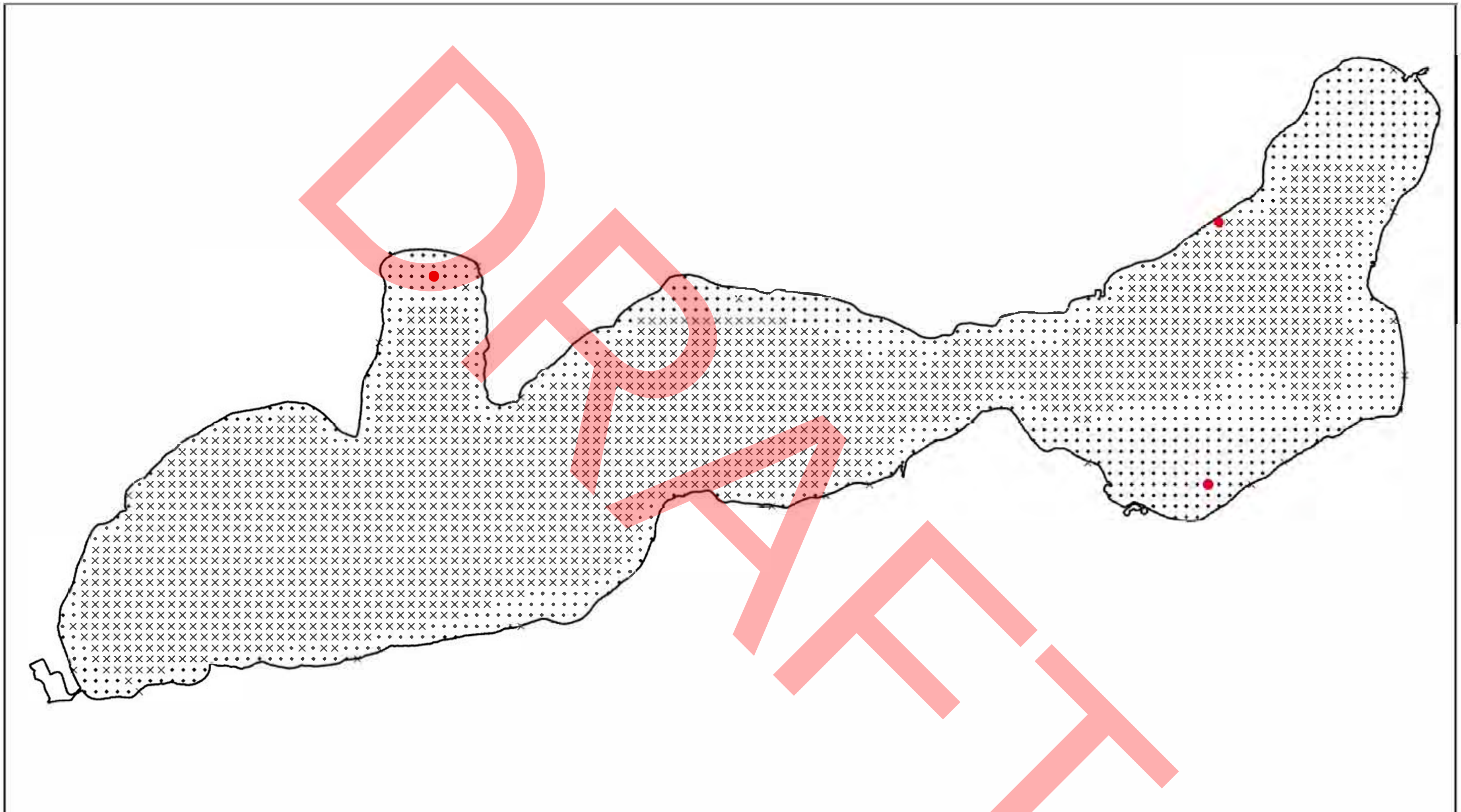
NO AQUATIC PLANTS FOUND

NOT SAMPLED



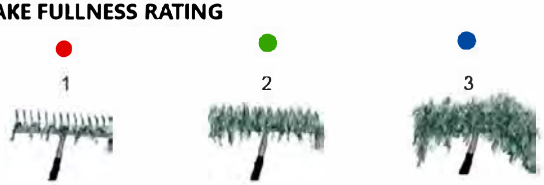
Source: WDNR and SEWRPC

Figure 2.34
Curly Leaf Pondweed Total Rake Fullness in Geneva Lake: July 2024



NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.

RAKE FULLNESS RATING



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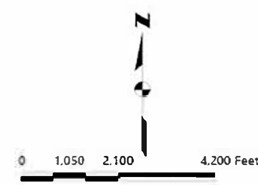
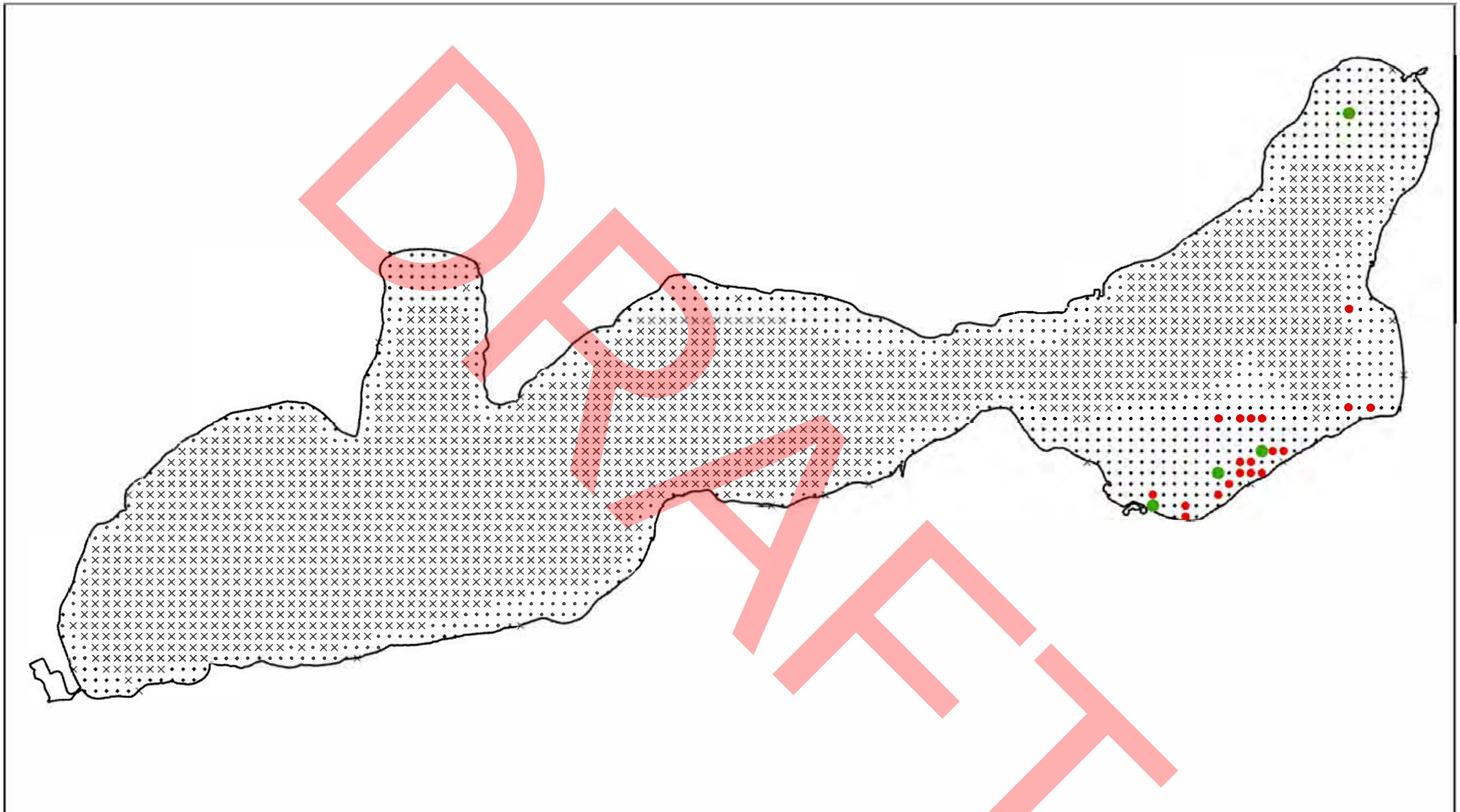


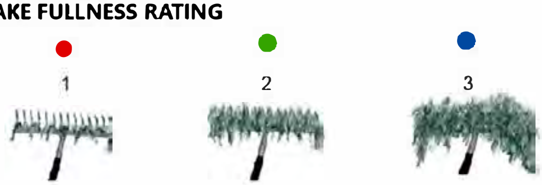
Source: WDNR and SEWRPC

Figure 2.35
Starry Stonewort Abundance in Geneva Lake: July 2024



NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.

RAKE FULLNESS RATING



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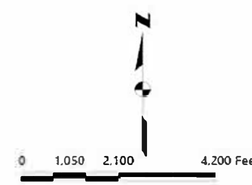
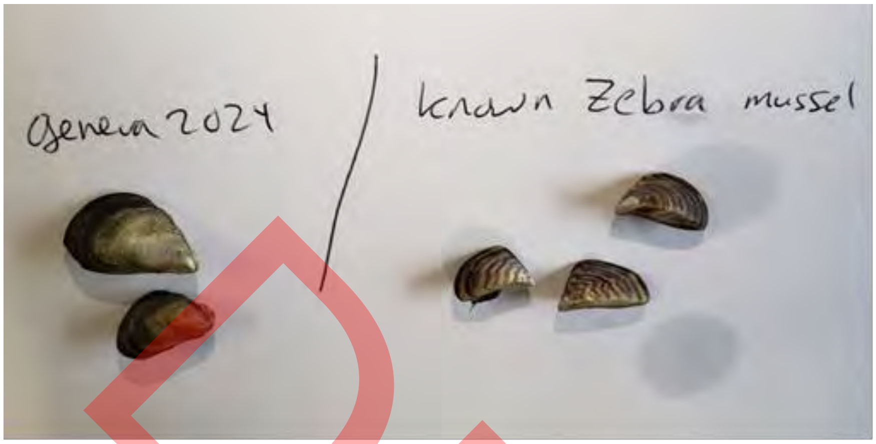


Source: WDNR and SEWRPC

Figure 2.36
Quagga Mussels (*Dreissena bugensis*) in Geneva Lake: 2024

Quagga mussels and Zebra mussels taken from Geneva Lake

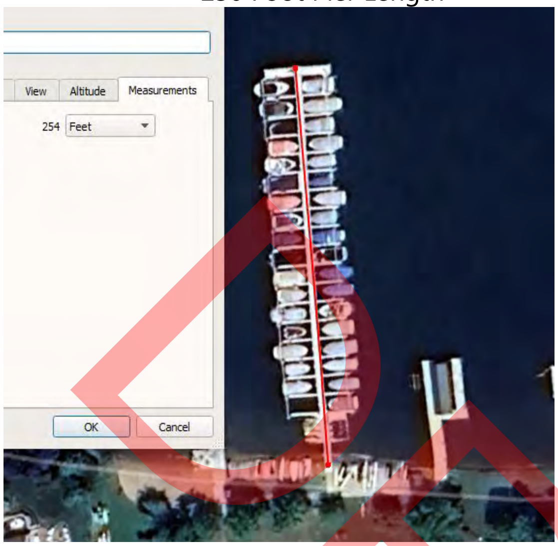


Geneva Quagga mussels in comparison to know Quagga mussel specimens

Source: WDNR and GLEA

Figure 2.37 Piers
Aerial Imagery of Piers on Geneva Lake: July 2023

~250 Foot Pier Length

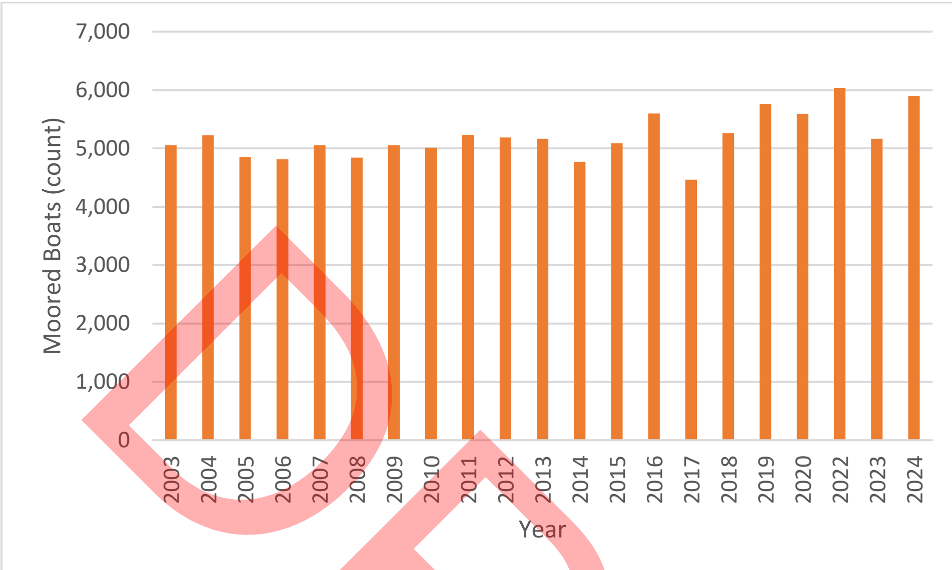


41 Moored Boats

Shaded Boat Canopies Along ~380 feet of Shoreline

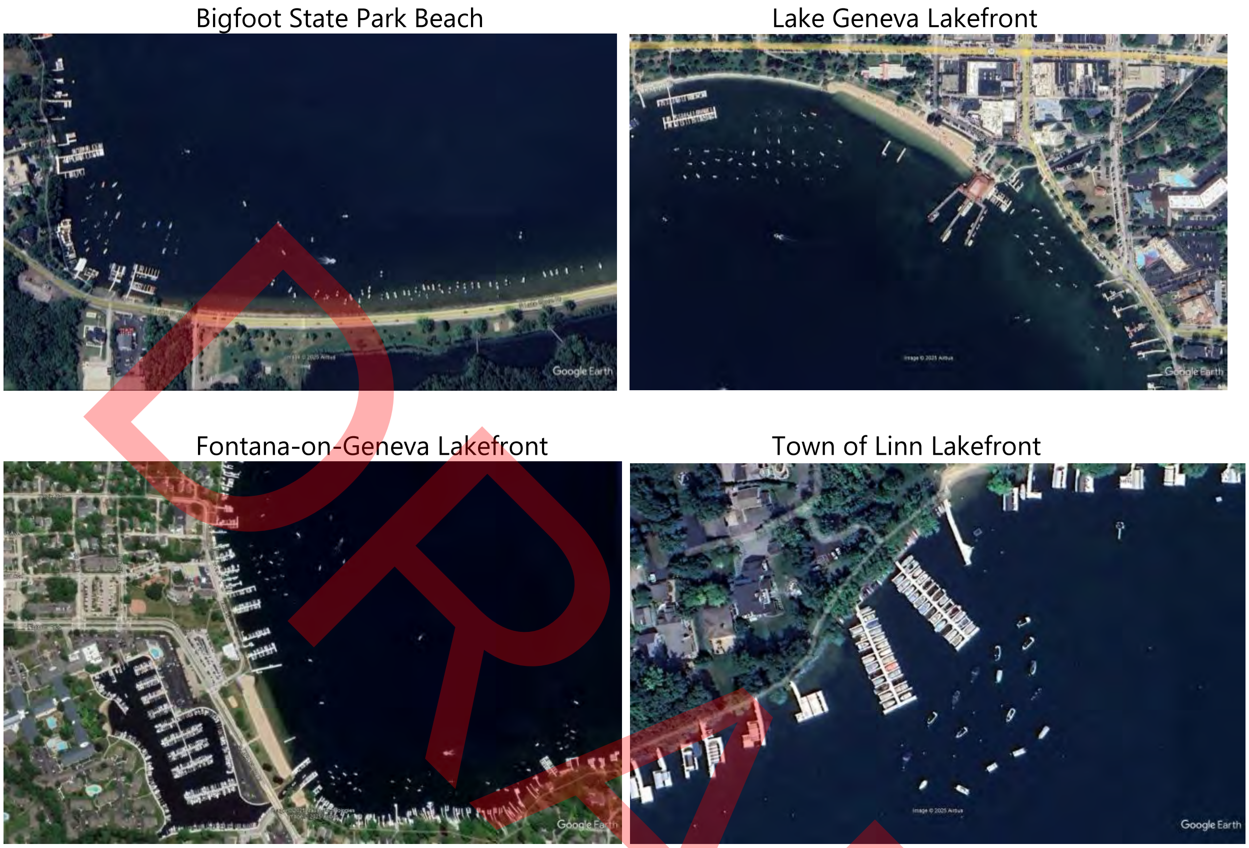
Source: Google Earth and SEWRPC

Figure 2.38
Moored Boat Count on Geneva Lake: 2003 - 2004



Source: WDNR and GLEA

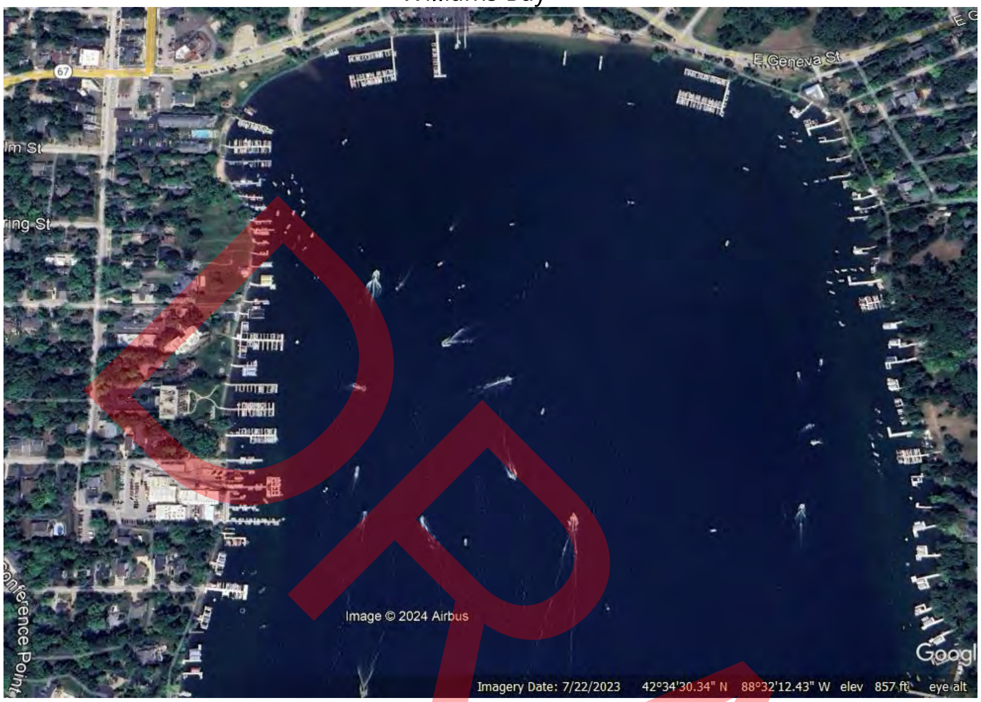
Figure 2.39
Aerial Imagery of Dense Moored Boat Areas on Geneva Lake: June 25, 2022 and July 22, 2023



Source: Google Earth and SEWRPC

Figure 2.40
Aerial Imagery of Dense Boating Traffic on Geneva Lake: July 22, 2023

Williams Bay



The Narrows

Source: Google Earth and SEWRPC

Chapter 3

MANAGEMENT RECOMMENDATIONS AND PLAN IMPLEMENTATION

3.1 INTRODUCTION

Geneva Lake is a valuable resource to lake residents and visitors, contributes to the local and regional economy and quality of life, and is an important feature to the overall hydrology and ecology of the watershed. Because of the Lake's value to the community, the Geneva Lake Conservancy requested, and was subsequently awarded, a grant to inventory the Lake's resource base and conditions, study issues perceived to harm or threaten the Lake and suggest solutions to help maintain or enhance the Lake's overall community value. Unmitigated human-induced change is generally detrimental to waterbody health. Therefore, management actions should be taken to counter negative effects of human activity.

As a planning document, this chapter provides concept-level descriptions of activities that may be undertaken to help protect and enhance Geneva Lake and its watershed. It is important to note that plan recommendations provide stakeholders and implementing entities with guidance regarding the type and nature of projects to pursue to meet plan goals. These recommendations and project suggestions do not constitute detailed technical specifications. The full logistical and design details needed to implement most recommendations must be more fully developed in the future when individual recommendations are implemented. Grants are often available to take concepts and produce actionable design drawings and plans.

To help implement plan recommendations, Table 3.1 summarizes all recommendations and their priority level while Figures 3.1, 3.2, and 3.3 provide a visual overview of where to target management efforts. Table

3.2 provides a table of select management recommendations with estimated costs, phosphorus reduction amounts (as relevant), potential funding programs, and suggested entities to implement the recommendations. Programs that may help fund recommended practices and programs are provided in Table 3.3.

In summary, this chapter provides 1) a context for understanding what needs to be done and the relative importance of plan elements and 2) information that will enable those implementing the plan to better envision what such efforts may look like and to more fully comprehend the overall intent. Such concepts can be invaluable for building coalitions and partnerships, writing competitive and meaningful grant requests, and initiating project design work.

3.2 HYDROLOGY, WATER QUANTITY, AND WATER RESOURCES INFRASTRUCTURE

Management plans that call upon practices that preserve, enhance, or naturalize watershed runoff, consider natural resource features and limitations, and promote thoughtfully engineered water resource infrastructure can benefit waterbody and watershed health and resilience in many ways. Such plans help managers choose alternative courses of action that slow runoff, detain stormwater, promote stormwater infiltration, sustain groundwater supplies, protect and enhance habitat value, and benefit recreational pursuits. A few examples of benefits accruing from such practices are listed below.

- Stormwater runoff intensity is reduced. This can reduce watercourse bed and bank erosion, lower sediment/nutrient loads, preserve topsoil integrity, foster soil water storage and groundwater recharge, protect infrastructure, and improve aquatic habitat value.
- Favorable soil moisture conditions are prolonged. This positively affects plant health and crop yields, especially during drier summers. Furthermore, less stormwater leaves the landscape as runoff, reducing downstream flooding and soil erosion.
- Groundwater recharge potential is maintained helping assure groundwater continues to flow at natural groundwater discharge points such as springs and seeps. Furthermore, maintaining groundwater recharge potential helps maintain aquifer water levels that assure reliable potable water supplies for human needs.
- Stream flow volumes are modulated and water quality is improved. Peak runoff volumes and flood elevations are reduced, dry-weather flows are increased, summer water temperatures are cooler, and winter water temperatures are sometimes slightly higher.

- Waterbody ecology is benefitted. Aquatic habitat health is promoted by the factors listed above allowing the waterbody to better reach its latent ecological potential.
- Recreational opportunities are maintained or increased. Healthy aquatic habitat supports more abundant, more diverse, and more desirable plants and animals.

Management strategies addressing the Lake's water supply and water elevation/storage volume should identify opportunities, quantify changes, and evolve over time. Data collected by systematic monitoring helps lake managers make decisions consistent with current conditions and trends. The following recommendations suggest practical strategies to protect and enhance the Lake's water supply and generate data needed to gage ongoing conditions.

Surface Water Monitoring and Management

➤ **Recommendation 1.1: Continue to monitor Geneva Lake's water surface elevation**

The Geneva Lake Level Corporation (GLLC) has monitored the Lake's surface water elevations and provided summarized reports on their website.[1] Continued monitoring is necessary, so that any issues can be detected early and a long-term Lake level record obtained. Automated lake level systems are available and may be useful to link to the GLLC and GLEA websites. Real time surface water elevation data would be useful for adapting the discharge rate to current weather conditions as well as better enforcement of boating ordinances. This recommendation is a high priority.

➤ **Recommendation 1.2: Continue to monitor and quantify the volume of water delivered to the Lake from the various (tributary) sub-basins**

At a minimum, stream flow should be quantified when water quality samples are collected. Additional measurements should be made to help quantify flow during fair weather, periods of heavy runoff, and dry weather. Runoff estimates can be made using empirical formulae or models. Additional measurements and modeling require substantial amounts of labor and/or cost. This recommendation is a medium priority.

[1] *https://genevalakelevel.com/*

Protecting Groundwater Supplies

Geneva Lake receives sizable contributions of groundwater that benefits the Lake's water quantity and quality as well as enhancing habitat for coolwater fish species. Additionally, the Lake is fed by Potawatomi and Van Slyke Creeks, which are both coolwater trout streams that are sustained by groundwater supply. To help protect the quantity and quality of groundwater discharging to Geneva Lake and its tributaries, management action must focus on the groundwatershed of the Lake, an area that extends substantially farther than the watershed to the west, northwest, and south (see Map 2.8). Appropriate management action in this area helps maintain groundwater recharge, avoids unsustainable groundwater extraction and export, and maintains high groundwater quality. Even if groundwater resources are carefully managed within the Geneva Lake groundwatershed, large-scale groundwater extraction beyond the groundwatershed can also influence the amount of groundwater entering and/or leaving the Lake and its tributaries. Therefore, activities already occurring or planned to occur near the Lake's groundwatershed should be scrutinized. Actions helping protect the groundwater supply include the following examples.

- **Recommendation 1.3: Institute groundwater monitoring**

  The United States Geological Survey (USGS) has maintained a groundwater monitoring well located in the Village of Fontana since 2019.[2] Other sources of groundwater elevation information are undoubtedly available throughout the watershed (e.g., monitoring wells servicing remediation sites, landfills, quarries). The GLEA and GLLC could request copies of historical and ongoing groundwater elevation measurements to provide additional coverage. Finally, emerging, affordable technologies are available to collect groundwater information in water supply wells.[3] Implementing an expanded monitoring program should be considered a medium priority.

  The groundwater supplying the Lake is also heavily used for potable and industrial water supply, a situation that diminishes the amount of groundwater entering natural waterbodies. Municipal and private high-capacity wells must report the volume of water pumped each year. The GLEA and GLLC should request copies of production records in the watershed and track historical, current, and future human groundwater demands. This will help chart the degree of stress placed on the water supplies feeding the Lake and should be considered a medium priority.

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[2] *https://waterdata.usgs.gov/nwis/inventory?site_no=423312088350401*

[3]*An example of groundwater elevation monitoring equipment can be found at the following website: www.wellntel.com. This reference does not constitute an endorsement of the products offered by this firm but rather is provided for general illustration.*

➤ **Recommendation 1.4: Curb growth of groundwater demand by carefully evaluating activities and developments that reduce groundwater supply to the Lake**

Groundwater supplies all residential, commercial, and industrial potable water demands in the Geneva Lake watershed. Additionally, much of the human population of this groundwatershed is served by public sanitary sewers which export wastewater to other watersheds. Therefore, some of the water pumped from local aquifers is exported from the local groundwatershed and no longer can supply baseflow to the Lake. This is a vexing problem that often increases over time and has few easy solutions. However, action can be taken to reduce current and future net demand placed on local aquifers. Examples of such concepts are provided below.

- Carefully vet the impact of new development, especially those using new high-capacity wells, on groundwater withdrawals in the Lake groundwatershed (see Map 2.8). The WDNR Water Quantity Data Viewer is an interactive web map that illustrates Public Land Survey Section Townships with active high-capacity wells as well as locations where proposed wells are pending approval.[4] Proposed wells in areas with high groundwater recharge and/or in primary environmental corridor should be reviewed for their impact on groundwater supplies to the Lake. The Village of Richfield in Washington County requires a professional analysis of development's impact on local groundwater elevations as a caveat to granting construction permits.[5] This should be assigned a high priority for projects within the Lake's groundwatershed.
- Evaluate activities within the Lake's groundwatershed that require long-term dewatering (e.g., quarry operations), especially if effluent water discharges to surface-water features draining to areas beyond the Lake's watershed. This should be assigned a high priority.
- Critically examine new commercial or industrial development proposals that use water consumptively or export water from the groundwatershed. This recommendation is assigned a medium priority.
- Discourage new residential water supply systems in the groundwatershed that rely on private on-site water supply wells yet discharge wastewater to wastewater treatment plants outside of the watershed. This should be assigned a low priority.

[4] *See the WDNR Water Quantity Data Viewer at the following link: https://dnrmaps.wi.gov/H5/?viewer=Water_Use_Viewer.*

[5] *More information of the Village of Richfield's groundwater protection program may be found at the following website: www.richfieldwi.gov/300/Groundwater-Protection.*

- Evaluate if any clean-water discharges now directed to sanitary sewers, or discharge points outside the watershed, can be redirected to discharge points within the area contributing surface water and groundwater to the Lake watershed. An example would be redirecting clean noncontact cooling water drawn from wells located in the groundwatershed to surface water within the watershed. Since few opportunities likely exist in this watershed, this recommendation is assigned a low priority.

➤ **Recommendation 1.5: Preserve or enhance groundwater supplies by enhancing infiltration and limiting development in environmental corridors and high groundwater recharge areas**

Given the significant quantity of groundwater recharge lost through human landscape manipulation, maintaining, or more desirably increasing, stormwater infiltration is very important. This action not only protects surface-water features, encourages stable stream channels, reduces soil erosion, and promotes ecological health, it also helps safeguard groundwater supplying the needs of the area's human population and businesses. Several examples of tactics that help preserve or enhance groundwater recharge follow.

- Lake stakeholders should continue to undertake actions promoting soil health. Healthy soils allow more stormwater to infiltrate and retain more nutrients and water benefitting crop growth. Healthy soils are characterized by greater aggregation, abundant soil macroinvertebrates like earthworms, higher root density, and higher concentrations of organic matter.[6] Promoting good soil health is most widely applicable to tilled agricultural lands within the watershed but the principles can also be applied to other lands such as parks and lawns. The GLEA and GLC could help support the growth of the WATERS, a recently formed producer-led group covering Walworth County.[7] The GLEA, GLC, and WATERS could collaborate on grant funding from DATCP or the WDNR Surface Water Grant program to implement agricultural practices that reduce soil loss and pollutant loading.[8] Soil health promotion should be assigned a medium priority.

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[6] *See Wisconsin Natural Resource Conservation Service, Testing for Soil Health, October 2017 for more information on testing soil health: www.efotg.sc.egov.usda.gov/references/public/WI/NRCS-Soil_Testing-508.pdf.*

[7] *For more information on WATERS and other producer-led groups, see the following link: datcp.wi.gov/Pages/Programs_Services/ProducerLedProjectSummaries.aspx#walworth.*

[8] *Lake districts and producer-led groups are both eligible to apply for WDNR Surface Water Grant program funding. Practices recommended in this plan are eligible for Surface Water Restoration and Management Plan Implementation grant funding. For more information, see the following link: dnr.wisconsin.gov/aid/SurfaceWater.html.*

- Preserve or enhance natural landscape features promoting groundwater recharge throughout the groundwatershed. Examples of such features include topographically closed depressions, natural areas, and well-vegetated open land as identified by primary and secondary environmental corridors as well as park and open space sites (see Maps 2.15 and 2.17). Such areas identified as having moderate, high, or very high groundwater recharge potential should be assigned high priority (see Map 2.8). The balance of such areas should be assigned a medium priority.
- Discourage widespread use of artificial drainage enhancement infrastructure (e.g., field tiles, piped storm sewers, drainage ditches, straightened streams) in areas within the groundwatershed with moderate, high, or very high groundwater recharge potential. Encourage naturalizing hydrology in such areas where such infrastructure already exists (e.g., wetland restoration, stream remeandering, drainage swales substituted for buried pipes). This recommendation should be assigned a medium priority.
- Promote careful control of new development in the watershed's best groundwater recharge potential areas (see Map 2.8). This helps ensure water supplying local and sometimes regional aquifers is protected. Control can include excluding certain types of development, maintaining recharge potential through thoughtful design, and minimizing impervious surface area. This should be assigned a high priority in areas with moderate, high, and very high groundwater recharge potential and a low priority in low groundwater recharge potential areas.
- Promote policies that protect or enhance infiltration on public and protected lands. High priority should be given to areas identified as having high and very high groundwater recharge potential within the groundwatershed feeding the Lake. Medium priority should be given to low groundwater recharge potential areas.
- Encourage local regulators to require developers to infiltrate high quality stormwater as an integral part of new development proposals. Water containing high concentrations of road deicers or other contaminants should not be infiltrated. Such stormwater management infrastructure is best located in areas of moderate, high, and very high recharge potential, where this recommendation should be assigned a high priority. Areas of low groundwater recharge potential should be assigned a medium priority.
- Encourage actions that retrofit existing stormwater conveyance systems in urbanized portions of the groundwatershed to promote high-quality stormwater infiltration. Good locations for retrofitted infiltration infrastructure are pockets of moderate, high and very high groundwater recharge potential within the Villages of Fontana and Williams Bay as well as the Town of Linn (see

Map 2.8). Activities consistent with this recommendation would be modifying existing municipal infrastructure or promoting actions that enhance infrastructure on existing properties. Examples of the latter would be disconnecting rooftop drains from piped stormwater conveyance systems and allowing stormwater to discharge to well-vegetated soil areas.[9] This should be assigned a high priority.

- Advocate for ordinances discouraging excessively broad expanses of impermeable surfaces and/or that consider lost infiltration potential created by development and offset this loss with high-quality runoff infiltration infrastructure located on the site or elsewhere within the groundwatershed. This activity should be assigned a medium priority.
- Purchase land or conservation easements on natural, agricultural, and open lands within the Lake groundwatershed identified as having very high or high groundwater recharge potential and that are desirable for protection for other purposes. Given the potentially high expense of this initiative, it is assigned a low priority.
- Continue to protect wetlands and uplands with an emphasis on preserving groundwater recharge by enforcing town, village, and city zoning ordinances. This activity should be assigned a high priority.

3.3 WATER QUALITY

Water quality is one of the key parameters used to determine the overall health of a waterbody. The importance of good water quality can hardly be overestimated, as it impacts not only various recreational uses of a lake, but also nearly every facet of the natural balances and relationships that exist in a lake between the myriad of abiotic and biotic elements present. Because of the importance water quality plays in the functioning of a lake ecosystem, careful monitoring of this lake element represents a fundamental management tool. The following section recommends measures to enhance water quality monitoring and management on the Lake (see Figure 3.2).

Water Quality Monitoring

Water quality is one of the key parameters used to determine the overall health of a waterbody. The importance of good water quality can hardly be overestimated, as it impacts not only various recreational

[9] *Rain gardens are depressions that retain water, are vegetated with native plants, and help water infiltrate into the ground. Rain gardens can help reduce erosion and the volume of unfiltered pollution entering a waterbody and can also help augment baseflow to waterbodies. Visit the Healthy Lakes program website for more information on best practices: healthylakeswi.com/*

uses of a lake, but also nearly every facet of the natural balances and relationships that exist in a lake between the myriad of abiotic and biotic elements present. Because of the importance water quality plays in the functioning of a lake ecosystem, careful monitoring of this lake element represents a fundamental management tool. The fact that Lake residents are concerned with various water-quality-related issues (e.g., sources of pollution in the watershed, algal growth, *E. coli*) suggests that water quality management is warranted on the Lake.

➤ **Recommendation 2.1: Enhance ongoing monitoring efforts through USGS and beach testing**

Water quality monitoring is an important tool that helps quantify the Lake's current condition, helps lake managers decipher longer term change, and allows the factors responsible for change to be identified. Monitoring is integral to management efforts aiming to maintain and improve Lake health. Therefore, monitoring water quality should be a high priority.

Currently, USGS is contracted to monitor the Lake's water quality in the western basin (see Map 2.20) It is recommended that the western basin monitoring be continued and enhanced when appropriate. At a minimum, water quality should be analyzed for the following parameters:

- Field measurements
  - Water clarity (i.e., Secchi depth)
  - Temperature (profiled over the entire water depth range at the deepest portion of the Lake)
  - Dissolved oxygen (profiled over the entire water depth range at the deepest portion of the Lake)
  - Specific conductance (near-surface sample)
  - pH (near-surface sample)
- Laboratory samples
  - Total phosphorus (near-surface sample)
  - Total nitrogen (near-surface sample)
  - Chlorophyll-a (near-surface sample)
  - Total suspended solids (near-surface sample)
  - Chloride (near-surface sample)

Laboratory tests quantify the amount of a substance within a sample under a specific condition at a particular moment in time and provide valuable benchmarks and trend-defining values. Phosphorus, nitrogen, and chlorophyll-a analyses are the basic suite of parameters used to determine and track overall lake health and trophic state. These parameters are tested in many Southeastern Wisconsin lakes and are useful to contrast the Lake's health to other waterbodies of interest.

Field measurements are often reasonable surrogates for common laboratory tests. For example, water clarity decreases when total suspended solids and/or chlorophyll-a concentrations are high, samples with high concentrations of total suspended solids commonly contain more phosphorus, and water with higher specific conductance commonly contains more salt and, therefore, more chloride. Periodically sampling water and running a targeted array of laboratory and field tests not only provides data for individual points in time but can also allow laboratory results to be correlated with field test results. Once a relationship is established between laboratory and field values, field data can sometimes be used as an inexpensive means to estimate the concentrations of key water quality indicators normally quantified using laboratory data.

Regular water quality monitoring helps Lake managers identify variations in the Lake's water quality, improves the ability to understand problems and propose solutions, and the capacity to track progress toward Lake water quality goals. The Lake's managers should review the water quality monitoring regimen and recommendations regularly and implement revisions to address changing conditions or new threats. Supplemental temperature/oxygen profiles collected at other times of the year (e.g., other summer dates, nighttime summer, fall, winter) can be helpful. For example, temperature/oxygen profiles collected during midsummer nights, just before sunrise, help evaluate diurnal oxygen saturation swings. Weekly monitoring of temperature and dissolved oxygen profiles during September and early October can examine the availability of cisco (*Coregonus artedi*) oxythermal habitat and inform decisions regarding the Lake's fishery management.

Beach monitoring is essential to ensure that public beaches are safe for recreational use by the public. Efforts to conduct beach monitoring and timely updates on beach conditions by the GLEA should be continued and supported.[10] Posted safety notifications and communication with local homeowners should also be considered for streams with high *E. coli* concentrations in which children are known to recreate. This is a <u>high priority</u>.

- **Recommendation 2.2: Continue water quality monitoring efforts in eastern basin of Lake**

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[10] *The GLEA posts updated beach conditions on its website at the following link: https://www.gleawi.org/about-4-1.*

The GLEA has contracted the USGS to conduct water quality testing in the Lake since 1988 (see Map 2.20). This testing was conducted in both the eastern and western basins of the Lake, but in the late 1990s water quality testing was stopped in the eastern basin of the Lake. As discussed in chapter 2, some aspects of water quality are similar but slightly different between the eastern and western basins of the Lake. For example, the eastern basin typically exhibits lower total phosphorus concentrations than the western basins. The USGS reinstated monitoring efforts in the eastern basin during the development of this lake management plan. Continuing these monitoring efforts is a medium priority.

➤ **Recommendation 2.3: Expand tributary water quality monitoring efforts**

As described in Section 2.4, "Water Quality," the GLEA has worked with the USGS and the University of Wisconsin-Whitewater to examine the water quality of the major Lake tributaries in 2021 and 2022. These efforts provided valuable data that informed the prioritization and recommendations of tributary projects in this management plan (see Section 3.4, "Pollutant Sources and Loads"). As pollutant load reduction measures recommended in this plan are implemented, Lake managers are recommended to maintain a tributary monitoring program to evaluate the effectiveness of these measures and to more quickly determine new issues as they arise. Incorporating additional pollutants, such as chloride, into this monitoring regime would help identify prominent sources of these pollutants in the watershed. These monitoring efforts could be supported through participation in the Water Action Volunteers program on perennial Lake tributaries (Bigfoot, Birches, Potawatomi, Southwick, and Van Slyke).[11] This recommendation is a medium priority.

➤ **Recommendation 2.4: Continue collaboration with municipalities, health officials, and WDNR regarding *E. coli* and algae monitoring**

As described in Section 2.4, "Water Quality," the GLEA currently monitors weekly *E. coli* concentrations at six locations across Geneva Lake (see Map 2.20). These results are shared with the local municipalities and posted on the GLEA website and social media pages to ensure that all Lake users are informed about water quality conditions in a timely manner.[12] This program provides an essential service to Lake users and its maintenance should be considered a high priority. Lake managers should also continue to

[11] *The University of Wisconsin Water Action Volunteers program is a volunteer-based water quality monitoring network focused on stream monitoring. For more information, see https://naturalresources.extension.wisc.edu/programs/water-action-volunteers-wav/.*

[12] *https://www.gleawi.org/about-4-1*

monitor for algal blooms and collaborate with WDNR and local health officials to provide appropriate and timely communication regarding lake conditions.

Phosphorus Management

Geneva Lake still maintains excellent water quality conditions but is showing indications of nutrient enrichment, such as increased phosphorus concentration and changes in its aquatic plant community. Reducing phosphorus loads to the Lake will help protect the Lake's excellent water quality.

- **Recommendation 2.5: Reduce nonpoint source phosphorus loads to the Lake**

  Algal growth in the Lake is limited by available phosphorus. Several techniques discussed below can be used to help maintain or lower phosphorus concentrations in the Lake. Related issues are discussed in Section 3.4, "Pollutant and Sediment Sources and Loads," Section 3.6, "Aquatic Plants," and Section 3.8, "Fish and Wildlife." Lower phosphorus concentrations generally decrease potential for algal blooms. Implementing these recommendations is critical to maintaining healthy algal populations and thus is assigned a high priority.

- **Recommendation 2.6: Manage factors that stimulate in-Lake phosphorus recycling**

  Available evidence suggests that phosphorus recycling and resuspension contributes substantial amounts of phosphorus to the Lake's water column. Several processes affect resuspension of phosphorus from lake sediment back into the water column including wind, common carp, boating, and the lack of aquatic vegetation on the lake-bottom sediment. Wind, boating, and common carp disturb bottom sediments while the lack of aquatic plants to act as sediment "groundcover" makes the sediment more susceptible to disturbance. Reducing in-lake phosphorus recycling through long-term watershed phosphorus load reduction measures and considering using in-lake measures should be considered a high priority. GLE

  While the most effective tool to reduce phosphorus recycling within the Lake over the long-term is reducing incoming phosphorus loads, several short-term management options may provide some temporary relief. However, these options are generally more expensive and will be rendered ineffective over time if ongoing phosphorus loading is not addressed. Given the current excellent Lake water quality, many of these techniques are not recommended at this time. Consequently, these large-scale interventions should only be considered if phosphorus concentrations and/or other trophic indicators show drastically worsening conditions.

- **Alum treatments** – Alum treatment involves dispersing a chemical (alum: hydrated potassium aluminum sulfate) throughout a lake. This chemical forms a flocculent solid that sinks, carrying solids to the lake bottom, allowing water to clear and rooted aquatic plants to grow at greater depth. Additional rooted aquatic plants uptake greater amounts of phosphorus and can help clear lake water in the longer term. Alum-bound phosphorus precipitated to the lake bottom does not become soluble under anoxic water conditions and can help form a cap to reduce internal phosphorus loading. These effects can help temporarily lower lake water phosphorus concentrations. Given the relatively small proportion of the phosphorus budget contributed to the Lake via internal loading (less than three percent), an alum treatment would likely not be an effective treatment option at this time. However, alum treatments should be considered if lake water quality conditions drastically deteriorate, as evidenced by an impairment listing for total phosphorus, significant nuisance growth of aquatic plants, or frequent and severe algal blooms.
- **Aeration** - This process involves pumping air to the bottom of a lake to disrupt stratification and limit the extent of anoxic conditions forming in the deep portion of the Lake. This in turn reduces internal loading (i.e., the release of phosphorus from deep sediments) and may reduce the severity of algal blooms during mixing periods. Traditionally, this method has produced mixed results in various lakes throughout Wisconsin and appears to be most successful in smaller water bodies such as ponds. However, recent developments in aeration technology to create smaller bubbles that persist in the water column longer and affect larger areas are being tested in central Wisconsin lakes.[13] Lake managers should stray abreast of these developments and related studies to determine if this technology may be appropriate to relieve issues related to algal blooms and low dissolved oxygen during late summer months.
- **Aquatic Plant Management** – Aquatic plants are the main competitors of algae for phosphorus and other nutrients; consequently, protecting the health of the aquatic plant community is a proactive measure to protect the lake's water quality. Mechanical harvesting of aquatic plants is not conducted on the Lake and is not currently recommended in this management plan. However, previous studies by the Commission have examined the capacity for aquatic plant harvesting to remove phosphorus from the Lake and found that it can be a significant phosphorus reduction tool

[13] *Wisconsin Public Radio,* Wisconsin community experiments with nanobubbles to clean up lakes, *September 2025. https://www.wpr.org/news/wisconsin-community-experiments-nanobubbles-clean-lakes*

for some lakes. If the aquatic plant community attains nuisance growth that warrants more wide-scale treatment, Lake managers are encouraged to consider utilizing mechanical harvesting as this technique provides an unintended benefit of reducing in-lake phosphorus loads.

- **Dredging** – Internal loading and resuspension of phosphorus depends on the availability phosphorus-rich lake bottom sediment. Dredging physically removes phosphorus-rich sediment from the waterbody and thus can reduce internal loading and recycling of phosphorus, particularly when the bottom sediment is continuously disturbed by common carp. Additionally, dredging could increase the lake volume and thus greater amounts of phosphorus would be required to attain the same concentrations as prior to dredging. However, dredging is very expensive, with estimated costs ranging from $5 to $25 per cubic yard. Dredging can also negatively affect lake ecology by removing aquatic vegetation and disrupting the habitat of aquatic organisms. Geneva's depth makes dredging costly and ill-suited for phosphorus management.
- **Water Level Manipulation** – Drawing down water levels can affect phosphorus levels within a lake via several pathways. Most directly, drawdowns can cause the exposed lake bottom sediment to consolidate and enhance decomposition of organic matter, reducing the fertility of the sediment once the water level is raised again. Reduced water levels can also enhance carp winterkill and control methods. Carp stir up lake sediment and consume aquatic vegetation. Manipulating water levels to mimic natural fluctuations can also encourage the growth of native submerged aquatic plant species, such as naiads and muskgrass, and enhance the expansion of emergent plant species like cattails and bulrush (see Section 3.5, "Aquatic Plants"). Lake managers need to carefully plan and monitor the frequency, intensity, and timing of water level drawdowns to reap the greatest benefits while also minimizing unintended harm. Significant water level manipulation is not a feasible strategy for phosphorus reduction as most of the Lake is lower than the minimum elevation of the outlet dam.

➤ Recommendation 2.7: Support septic system inspection, pumping, and maintenance efforts

Unmaintained septic systems are a source of phosphorus to Geneva Lake. Walworth County regulates septic system usage and requires inspections, pumping, and maintenance of these systems every three years.[14] The County and Linn Sanitary District work together on inspecting septic systems within the Lake watershed.[15] These efforts should continue to be supported to ensure that all septic systems are

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[14] *For more information on Walworth County regulation of septic systems, see https://www.co.walworth.wi.us/535/Sanitation.*

[15] *https://townoflinn.wi.gov/sanitary-district/*

on a regular inspection and maintenance schedule and that failing systems are addressed to reduce pollutant loads to the Lake. This recommendation should be considered a medium priority.

Chloride Management

Chloride concentrations in the Lake have increased over time, consistent with many other lakes within Southeastern Wisconsin. Chloride is a conservative pollutant meaning that there are no natural processes that will break it down within the Lake and removal of chloride is prohibitively expensive in most cases, particularly for as large of a waterbody as Geneva Lake. Thus, reduction of chloride inputs is the most effective management strategy to reduce chloride concentrations in the Lake. With a lake residence time of nearly fourteen years, chloride concentrations are likely to remain elevated for several years even if significant reductions in chloride application occur immediately. Elevated chloride concentrations are likely already affecting the lake biology, as the phytoplankton and zooplankton that form the base of the lake's food web can be very sensitive to increased chloride concentrations.[16] The following recommendations specifically address chloride management:

- **Recommendation 2.8: Municipalities and Walworth County should continue to reduce road salt applications using innovative practices**

  Road salts and deicers are likely a major source of chloride pollution to Geneva Lake. Several municipalities in the watershed have already been reducing their road salt applications, with the Town of Linn and the Village of Walworth being recognized as "Salt Wise Municipal Champions" by Wisconsin Salt Wise.[17] The Town of Linn creates its own brine mixture, annual calibrates its vehicles, and installed temperature sensors and liquid applicators to its vehicles; a 2020-2021 case study showed a 25 percent reduction in chloride application to roads.[18] The Village of Walworth also creates its own brine and developed applicators to pre-treat sidewalks and roads, resulting in an 85 to 90 percent reduction in salt application per event. Walworth County, which treats major thoroughfares in the watershed like STH 50 and 67, has also been recognized by Wisconsin Salt Wise for its training efforts and smart salting practices that have reduced salt use by 40 percent since 2019. The City of Lake Geneva has also reduced salt applications to roads by 60 percent over the past decade through brining, calibrations of de-icing equipment, and reducing application rates.[19] These efforts should be continued and adopted by the

[16] *SEWRPC Technical Report No. 62,* Impacts of Chloride on the Natural and Built Environment*, April 2024.*
[17] https://wisaltwise.com/Take-Action/Winter-Maintenance-Professionals/Municipal-Champions
[18] *https://wisaltwise.com/documents/PDFs/Town-of-Linn-Case-Study.pdf*
[19] *https://www.lgutilitycommission.com/wastewaterutility/chloride-program*

other municipalities providing services to roads within the Lake watershed. This recommendation is a high priority.

➤ **Recommendation 2.9: Reduce private and public salt applications by educating businesses and property owners about practicing smart salt management**

Private salt application on parking lots, private roads, driveways, and sidewalks can contribute substantial amounts of chloride to surface waters if the application rates are not properly managed. Using salt best management practices, such as calibrating salt spreading equipment, using road salt alternatives when practicable, and storing materials away from surface waters, should be encouraged. Additionally, private road owners should consider limiting or ceasing their salt applications on roads adjacent to the Lake. Alternative practices, such as more frequent snow clearing, adding sand to enhance traction, and using heated pavement in areas with persistent ice formation, should be considered to facilitate access but also reduce the environmental impacts to the Lake. Salt applicators should also be encouraged to undergo winter salt certification training, hosted by Wisconsin Salt Wise.[20] The GLC and GLEA provide educational materials on appropriate deicing practices for homeowners through the Keep It Blue program and the Geneva Lake Stewardship Guide, respectively.[21,22] This recommendation is a high priority.

➤ **Recommendation 2.10: Optimize water softeners for water use and hardness levels and upgrade to high-efficiency softeners when practical**

Residential and commercial water softeners have been shown to be a major chloride source, particularly in areas with hard water such as Southeastern Wisconsin.[23] Water softeners should be optimized for their water use and hardness levels, which can reduce their chloride discharge by up to 50 percent. Municipalities and their associated wastewater treatment facilities within the Lake watershed should consider adopting the approach utilized by the City of Waukesha, which is cost-sharing water softener optimization with local water conditioning companies. Subsequently, the City's residents only need to

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[20] *For a more complete list of salt best management practices and information on the Wisconsin Salt Wise winter salt certification program, see https://www.wisaltwise.com/.*

[21] *https://www.genevalakeconservancy.org/keep-it-blue*

[22] *Geneva Lake Environmental Agency,* Geneva Lake: A Stewardship Guide*, 2025. See the guide at the following link: https://www.gleawi.org/geneva-lake-data.*

[23] *A. Overbo, S. Heger, S. Kyser, et al.,* Chloride Concentrations from Water Softeners and Other Domestic, Commercial, Industrial, and Agricultural Sources to Minnesota Waters*, Minnesota Water Quality Association, 2019.*

pay a nominal $10 copayment to optimize their water softeners.[24] When water softeners are too old for optimization to have much effect, replacing the old softeners with high-efficiency softeners should be considered to reduce chloride discharge. At the time of plan writing, the Lake Geneva Utility Commission has a similar program offering a $200 rebate to customers that switch to on-demand regenerating water softeners as well as free adjustments to existing softeners to decrease the chloride loads transmitted to their wastewater treatment facility.[25] This recommendation is a high priority.

3.4 POLLUTANT SOURCES AND LOADS

Geneva Lake has excellent water quality but is showing signs of nutrient enrichment stemming from increased phosphorus and sediment loading across its watershed. The Lake's tributaries, particularly Bigfoot Creek and those draining agricultural lands, have been identified as the primary source of phosphorus to the Lake. With the exception of Bigfoot Creek, much of this pollutant loading is driven by intense precipitation events that have caused significant erosion in the Lake's steeply sloping tributaries. The following section will address how phosphorus and sediment loading can be addressed via practices and programs on agricultural, urban, residential, and natural land uses (see Figures 3.1 and 3.3).

Forthcoming Fox River Total Maximum Daily Load

The U.S. Environmental Protection Agency (USEPA) and the WDNR are in the process of establishing a total maximum daily load (TMDL) to improve conditions producing low dissolved oxygen and degraded habitat in the Fox River basin.[26] A TMDL allocates the allowable load between point sources such as municipal wastewater treatment plants, industrial dischargers, concentrated animal feeding operations, and municipal separate storm sewer systems (MS4s); nonpoint sources such as agricultural sources, urban sources not covered under a discharge permit, and natural background loads; and a margin of safety. The forthcoming Fox River TMDL will likely address impairments such as oxygen depletion, nuisance algae growth, reduced populations of submerged aquatic vegetation, water clarity problems, and degraded habitat resulting from high concentrations of total phosphorus and sediment. This TMDL will establish annual baseline total phosphorus and total suspended sediment loads and sets reduction goals for nonpoint sources, wastewater treatment facilities, and MS4s for both total phosphorus and total suspended solids. These load reduction

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[24] *For more information on the City of Waukesha's Water Softener Salt Program, see https://www.waukesha-*wi.gov/government/departments/softener-salt-program.php

[25] *https://www.lgutilitycommission.com/wastewaterutility/chloride-program*

[26] *For more information on the Fox River TMDL, see the WDNR webpage for the program at https://dnr.wisconsin.gov/topic/TMDLs/FOXIL.*

goals should be considered the minimum standard that communities and permitted entities strive to attain. Additionally, while these load reductions targets are important for establishing water quality goals, it is equally important to recognize that continued phosphorus and sediment monitoring are the ultimate determinant of water quality within the watershed.

- **Recommendation 3.1: Permitted facilities should consider using an adaptive management approach to meet TMDL requirements**

  Choosing a management strategy is critical to meeting water quality goals, including requirements on permitted facilities that are established by the TMDL. An example from a nearby community responding to its TMDL requirements is the City of Oconomowoc in Waukesha County. Oconomowoc has identified adaptive management as the preferred compliance alternative to meet its WPDES permit requirements for its wastewater treatment facility and MS4 under Chapters NR 217, "Effluent Standards and Limitations for Phosphorus," and NR 216, "Storm Water Discharge Permits," respectively, of the Wisconsin Administrative Code. The adaptive management plan spans three WPDES permit terms or 15 years, with the understanding that progress can be demonstrated by the beginning of the third term.

  In order to achieve these water quality goals, the City has developed the Oconomowoc Watershed Protection Program to build capacity and develop collaborative projects within the watershed.[27] This program works with local land trusts and producer-led groups to cost-share and implement agricultural best management practices like those described later in this Section as well as fund stream restoration projects that improve floodplain connectivity and reduce phosphorus loads. Similar programs established for the Fox River watershed could become a valuable mechanism to fund and implement phosphorus and sediment reduction practices across the Geneva Lake watershed. This recommendation should be considered a high priority.

Agricultural Non-Point Source Loads

Pollutant load modeling presented in this plan as well as previous editions of this management plan have identified agricultural nonpoint sources as major contributors to total phosphorus and sediment pollution to Geneva Lake. Consequently, utilizing agricultural BMPs and regenerative agriculture techniques are the

[27] *https://oconomowocwatershed.com/*

most effective measures to reduce nonpoint source pollutants and improve the water quality within the watershed.

Existing runoff management standards have been established by the State of Wisconsin and are administered by the WDNR and DATCP. Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* provides runoff management, nutrient management, soil erosion, tillage setback, as well as implementation and enforcement procedures for the regulations. Chapter ATCP 50, "Soil and Water Resource Management Program," of the *Wisconsin Administrative Code* prescribes farm conservation practices that can be used to implement these standards.[28] Although this plan recognizes the importance of continued funding and staff to ensure adherence to State, County, and local standards, it goes beyond reliance on regulation and enforcement. This watershed plan's strategy is to rely on empowered local decision makers creating unique solutions that work for the Geneva Lake watershed to ultimately exceed compliance standards. This strategy is designed to augment the work of Walworth County staff who work with landowners and operators to implement innovative and effective conservation practices continued through collaboration amongst the County, State, and Federal agencies. Glacierland RC&D, WATERS, and other partners could be involved as feasible to assist with education and outreach to producers as well as cost-share agricultural BMPs.

- **Recommendation 3.2: Continue to assist landowners to prepare and implement conservation plans and conservation practices needed for compliance with NR 151**

  Walworth County staff currently assist producers to reach compliance with NR 151. This assistance should continue based on the strategy articulated in the Walworth County Land and Water Resource Management Plan. This recommendation should be considered a high priority.

- **Recommendation 3.3: Incentivize use of no-till and conservation tillage practices and assist farmers and/or landowners in seeking funding for implementing such practices**

  Removing crop residue and disrupting soil through tillage often enables soil erosion. When soil is tilled, the soil structure resisting erosion is weakened and more soil is exposed to erosive forces, leading to nutrient and sediment laden surface runoff. No-till farming is the practice where soil is undisturbed except for where the seed is placed in the soil, which disturbs less than 15 percent of the row width. The combination of minimal ground disturbance and minimal removal of crop residue contribute to a

[28] *For more information, see docs.legis.wisconsin.gov/statutes/statutes/91/v/80.*

more stable soil surface that is less susceptible to erosion and the accompanying runoff of nonpoint source pollutants.

To be effective, no-till must be done as part of a system of crop rotation, nutrient management, and integrated pest management. Managing weeds and the residue resulting from no-till requires the farmer to be committed to changing additional seemingly interdependent farming practices as well as renting or purchasing new equipment or modifying existing equipment. These changes are not only a financial risk to farmers but also require that agricultural retailers, crop advisors, and local markets provide necessary training, equipment, and products to assist farmers transition to no-till. Walworth County staff and local partners should incentivize the use of reduced tillage and no-tillage practices to minimize soil erosion from their fields and mitigate pollutant loading to the Lake and its tributaries. This recommendation should be considered a medium priority.

➤ **Recommendation 3.4: Promote increased cover crop acreage and assist farmers and/or landowners in seeking funding for implementing such practices**

Establishing cover crops includes planting grasses, legumes, forbs or other herbaceous plants for seasonal cover and conservation purposes. Common cover crops used in Wisconsin include winter hardy plants such as barley, rye, and wheat as well as less common crops like oats, spring wheat, hairy vetch, red clover, turnips, canola, radishes, and triticale.[29, 30] Cover crops help reduce phosphorus and sediment loads to waterbodies by reducing erosion and improving infiltration. Cover crops grow during months when cultivated fields would otherwise be bare. This allows such fields to capture solar energy during fallow periods, a situation helping nourish soil biota, hold nutrients that otherwise would be carried away in water, and hold soil protecting it from erosion. When used properly for erosion control, cover crops produce a near continuous vegetative ground cover protecting soil against raindrop impact as well as sheet and rill erosion

Recent findings of the USDA Sustainable Agriculture Research and Education program recommend that a variety of strategies be employed to encourage agricultural producers to plant cover crops. Education, sharing new research results, appropriate technical assistance, low-cost seed, and in some cases, financial incentives will be necessary to encourage more farmers to adopt cover crops.[31] The GLA has

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[29] *USDA NRCS Wisconsin,* Cover Crops Factsheet, *2014.*

[30] *See UW-Extension website for more information at www.fyi.uwex.edu/covercrop*

[31] *Download USDA report at website www.ctic.org/media/web/1533827451_2016_CTIC_Cover_Crop_Report.pdf.*

previously sponsored use of cover crops on farm fields within the Lake watershed. This effort is applauded and encouraged to continue. Additional efforts could include sponsoring producer-led educational events that focus on cover crop application. Furthermore, the GLA, GLC, and GLEA could consider cooperating with Walworth County, and WATERS to make specialized equipment needed for cover crop application available to producers at low cost. Other counties have acquired such equipment and rent it to producers at a nominal cost.[32] This recommendation should be considered a medium priority.

- **Recommendation 3.5: Ensure all agricultural lands employ nutrient management plans and assist farmers in preparing and implementing these plans**

The goal of a nutrient management plan is to avert excess nutrient applications to cropland and to thereby reduce nutrient runoff to lakes, streams, and groundwater.[33] Nutrient management plans consider the amounts, types, and timing of nutrient applications needed to obtain desired yields and minimize risk of surface water and groundwater contamination. In Wisconsin, nutrient management plans are based on the NRCS 590 standard.[34] Plans must be prepared by a qualified planner, which may be the farmer or a certified crop advisor. Soil testing is done on each field to help producers identify where nutrients are needed and where they are not and considers tillage, manure application, and residue management practices. Plans help farmers allocate nutrients economically (i.e., right source, rate, time, and place) while also helping to ensure they are not over-applying nutrients which could cause water quality impacts.[35] This recommendation should be considered a high priority.

- **Recommendation 3.6: Install additional grassed waterways, maintain existing waterways, and assist farmers and/or landowners seeking funding to implement such practices**

Grassed waterways carry runoff water off fields in a way that limits soil loss. Grassed waterways are constructed in natural drainage ways by grading a wide, shallow channel and planting the area to sod-

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[32] *As an example, Ozaukee County and the Milwaukee River Clean Farm Families producer-led group offer a variety of incentives to encourage farmers to experiment with cover crops. Some of these programs are summarized at the following website: www.cleanfarmfamilies.com/cover-crop-program.*

[33] *For more information on nutrient management and planning, see datcp.wi.gov/Pages/Programs_Services/NutrientManagement.aspx.*

[34] *Wisconsin Natural Resources Conservation Service,* Conservation Practice Standard: Nutrient Management Code 590, *CPS 590-1, 2015, datcp.wi.gov/Documents/NM590Standard2015.pdf.*

[35] *As an example of a tool to help farmers apply at the "right time," DATCP produced the Runoff Risk Advisory Forecast which uses soil moisture, temperature, landscape characteristic, and precipitation data to determine the risk of runoff in the present and near future. This tool can prevent inadvertent nutrient loss by warning producers of unsuitable nutrient application conditions. For more information, see .www.manureadvisorysystem.wi.gov/runoffrisk/index.*

forming grasses. Effective grassed waterways convey runoff water from fields and the sod helps capture entrained sediment and prevents runoff from eroding a channel and forming a gulley. The vegetation may also absorb some chemicals and nutrients in the runoff water and provide cover for small birds and animals. Grassed waterways fill with sediment over time and need to be rejuvenated by removing sediments, regrading, and replanting. Based on Commission staff estimates, the Lake watershed already contains 13,465 linear feet of grassed waterways (see Figure 3.4). Installing additional grassed waterways, particularly within steeply sloped cultivated fields where gully erosion is already evident, can further reduce phosphorus and sediment loading to surface waters. This recommendation should be considered a medium priority.

➤ **Recommendation 3.7: Install additional water and sediment control basins, maintain existing basins, and assist farmers and/or landowners seeking funding to implement basins**

Water and sediment control basins are typically earthen embankments constructed across the slope of a field to arrest gully formation and soil erosion. These basins detain field runoff and allow suspended sediment within that runoff to settle out. Installing additional water and sediment control basins in combination with grassed waterways on steeply sloped fields can reduce phosphorus and sediment loading to surface waters. Potential areas where water and sediment control basins may be particularly useful are steeply sloping agricultural fields and particularly where gully erosion may already be evident. Given the prevalence of steeply sloped agricultural fields in the watershed, this recommendation should be considered a high priority.

Animal Operations

In Wisconsin, an animal feeding operation with 1,000 or more animal units is defined as a Concentrated Animal Feeding Operation (CAFO).[36] Under State and Federal law, CAFOs must have a WDNR-issued Wisconsin Pollutant Discharge Elimination System (WPDES) permit to protect surface and ground waters from excessive runoff and animal waste. Consequently, CAFOs are more stringently monitored and regulated than smaller animal feeding operations. Among the requirements are that CAFOs have a nutrient management plan developed as part of the permit process; that response plans are developed for manure and non-manure spills; that manure spreading limits and setbacks are specified; and that additional

[36] Wisconsin Administrative Code *NR 243 Animal Feeding Operations relates an animal unit to the impact of one beef steer or cow. Therefore, 1000 beef cattle are equivalent to 1000 animal units. Other animals have differing ratios. For example, the following numbers of animals are equivalent to 1000 animal units: 500 horses, 715 dairy cattle, 5,000 calves, 5,500 turkeys, 10,000 sheep.*

inspection, monitoring, and reporting requirements are adhered to.[37] There are two CAFOs with fields within the Geneva Lake at the time of this writing. Walworth County staff should continue to work with the WDNR to address any concerns about water quality impacts from animal operations in the watershed.

➤ **Recommendation 3.8: Ensure that animal operation performance standards are met**

The provision for barnyard runoff control systems and six months of manure storage are recommended for all livestock operations in the watershed as well as maintaining exclusion of livestock from waterbodies and adjacent riparian areas. Animal waste storage, management, and utilization must comply with Walworth County ordinances.[38] To assist with enforcement, citizens and volunteers can report suspected violations to County or State authorities. Furthermore, it is recommended that WDNR and DATCP consider increasing levels of cost-share funding to enable a higher level of BMP implementation needed to meet the NR 151 performance standards. This recommendation should be considered a high priority.

Urban Non-Point Source Loads

Historically, the approach to manage increases in rates and volumes of runoff within urbanized areas often involved constructing storm sewer and/or open channel systems to quickly convey stormwater to streams or lakes. In recent years, flooding, water quality impairment, and environmental degradation demonstrate the need for an alternative approach to urban stormwater management. Consequently, present-day stormwater management approaches seek to manage runoff using a variety of measures, including detention, retention, infiltration, and filtration, better mimicking the behavior and disposition of precipitation on a more natural landscape. The predominantly suburban nature of the watershed and proximity of urban land uses to the Lake make these best management practices important for enhancing Lake water quality. The following recommendation address reducing urban nonpoint pollutant loads in the watershed:

➤ **Recommendation 3.9: Encourage urban pollution source reduction efforts through BMPs**

Reduce lawn fertilizer use, create rain gardens, and properly store and judiciously apply deicers and other chemicals to prevent them from washing into the Lake. Additional BMP examples are provided in the recommendations below. The GLC and GLEA provide educational materials on practices that reduce

[37] *For more information, see dnr.wisconsin.gov/topic/CAFO/WPDESNR243.html.*

[38] *Walworth County Code of Ordinances Chapter 6 Article IV, "Animal Waste Storage." For more information see library.municode.com/wi/walworth_county/codes/code_of_ordinances?nodeId=WACOCOOR_CH6AN_ARTIVANWAST.*

phosphorus and salt loading for homeowners through the Keep It Blue program and the Geneva Lake Stewardship Guide, respectively.[39,40] This recommendation should be considered a high priority.

- **Recommendation 3.10: Inventory existing stormwater management practices and develop stormwater management plans**

Given the predominance of steeply sloping suburban and urban lands in the Geneva Lake watershed, stormwater management is especially important for reducing soil erosion and mitigating pollutant loads to the Lake. However, only the Village of Fontana currently has a stormwater management plan and there has not been a watershed-wide effort to inventory existing stormwater management practices. Gathering this information and developing plans for the other municipalities along the Lake will help identify areas of concern as well as opportunities to enhance stormwater practices. This should be considered a medium priority.

- **Recommendation 3.11: Promote native plantings in and around existing and new stormwater detention basins**

Planting native plants in these situations improves detention water filtration, reduces pollutant loading, and provides wildlife habitat. In addition, detention basin management practices should aim to reduce or eliminate fertilizing basin slopes and limit herbicide application and cutting to invasive species only. This should be considered a medium priority.

- **Recommendation 3.12 Retrofit existing and enhance planned stormwater management infrastructure to benefit water quality**

Water quality can benefit by extending detention times, spreading floodwater, and using features such as grassed swales to convey stormwater. Implementing such works requires close coordination with the municipalities within the Geneva Lake watershed. This recommendation should be considered a high priority.

- **Recommendation 3.13: Combine riparian buffers with other structures and practices**

A much higher level of pollution removal can be achieved with “treatment trains” combining riparian buffers with better-managed detention basins or new practices such as floating island treatments,

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[39] *https://www.genevalakeconservancy.org/keep-it-blue*
[40]*GLEA, 2025,* op. cit, *https://www.gleawi.org/geneva-lake-data*.

grassed swales, and infiltration facilities. This layering of overlapping practices and structures is a more effective way to mitigate the effects of urban stormwater runoff than such practices being used in isolation. This action should be assigned a low priority.

- **Recommendation 3.14: Stringently enforce construction site erosion control and stormwater management ordinances and creatively employ these practices**

Ordinances must be enforced by responsible regulatory entities in a manner consistent with current practices; however, local citizens can help by reporting potential violations to the appropriate authorities. This recommendation should be considered a low priority.

- **Recommendation 3.15: Maintain stormwater detention basins**

Maintaining stormwater basins includes managing aquatic plants, removing and disposing of flotsam or jetsam, ensuring adequate water depth to settle and store pollutants, inspecting and repairing outlet structures, and actively and aggressively managing excess sediment. Specifications associated with the design of stormwater detention basins and maintenance requirements ensure that basins are functioning properly.[41] It is important to remember that stormwater detention basins occasionally require dredging to maintain characteristics that protect the Lake. The frequency of dredging is highly variable and depends upon the design of the basin and the characteristics of the contributing watershed. Regulatory entities should complete basin inspection in a manner consistent with current practices; however, ensuring that the owners of these basins know the importance of meeting these requirements through educational outreach can help ensure continued proper functioning of the ponds. Coordinating with municipalities and neighborhood associations can play an important role. This should be considered a low priority due to the few basins located in the watershed.

- **Recommendation 3.16: Collect leaves in urbanized areas on both private and public property**

Leaves have been shown to be a very large contributor to total external phosphorus loading to lakes in urban settings. Stockpiling leaves in the street where they may be crushed and washed into the Lake or burning leaves in shoreline and ditch areas can create situations where a strong pulse of phosphorus is delivered to the Lake by late autumn rains. Residents should be encouraged to use leaf litter within their own yards as a nutrient source or much or should take advantage of the yard waste collection and leaf

[41] *Technical standards for design and maintenance of wet detention basins and other stormwater management practices can be found at www.dnr.wi.gov/topic/stormwater/standards/postconst_standards.html.*

disposal programs in existence in those municipalities in the watershed that conduct such programs, such as the City of Lake Geneva and the Villages of Fontana and Williams Bay. This recommendation should be considered a low priority.

Tributary Loading

Commission staff prioritized the Lake tributaries based on available water quality data and pollutant load modeling estimates (see Map 2.7 and Figure 3.3). The following list can be used to help guide the priority of implementation projects intended to improve stream morphology and mitigate pollutant loading to the Lake. Recommendations for specific projects and locations on the tributaries can be found in the "Tributary-Specific Recommendations" section.

1. Bigfoot Creek - This creek is the highest priority due to its documented poor water quality conditions and high modeled pollutant loading.

2. Birches Creek and its tributaries – This creek measured high for total phosphorus loading and high modeled loading of phosphorus.

3. Abbey Springs - This creek has high total phosphorus concentration measured after precipitation events.

4. Trinke Creek – This creek has measured high for total phosphorus concentrations following precipitation events and also had high modeled total phosphorus loading.

5. Gardens Creek – The creek had high measured nitrate and nitrite concentrations in addition to high modeled total phosphorus loading.

6. Southwick Creek – This creek had high total suspended solids (TSS) concentrations during runoff, moderately high TP loading

7. Potawatomi and Van Slyke – These creeks have documented streambank erosion and total phosphorus loading concerns. These creeks should be targeted for management to protect their statuses as WDNR designated trout streams.

8. Remaining tributaries – The monitoring, surveying, study and management of the remaining tributaries should be prioritized roughly by size of contributing drainage area and willingness of riparian land owners to implement project. The general recommendations outlined below along with some outlined under specific tributaries may also be applicable to other tributaries in the Lake's watershed that have similar issues.

- **Recommendation 3.17: Control invasive buckthorn and honeysuckle along tributary corridors**

Both invasive buckthorn and honeysuckle species can form dense thickets, reducing light availability for understory species and preventing native tree regeneration. Additionally, these species compete for soil moisture and nutrients with native vegetation (see Figure 3.5). Removing nonnative species will allow native species to regenerate and stabilize tributary corridors. This recommendation should be a considered a high priority.

- **Recommendation 3.18: Reduce and slow stormwater contributions into tributaries**

Stormwater and runoff can introduce pollutants into the creeks. Sediment washed into the tributaries can not only deposit in the channels but also cause phosphorus loading. High velocity stormwater flows can erode streambanks causing channels to form ravines. Multiple practices can be utilized to slowing water in upland areas, including constructing water and sediment control basins on sloping farmland, stormwater detention ponds near Creek headwaters, and road diversions as well as either disconnecting drain tiles or installing in-line control systems (see Figure 3.6). This recommendation should be considered a high priority, particularly for the many steeply sloping ravine streams in the watershed.

- **Recommendation 3.19: Utilize regenerative stormwater conveyance practices**

Many of the Lake tributaries are steep ravine streams that are experiencing significant erosion and head cutting during and following intensive precipitation events.[42] Regenerative stormwater conveyance is an engineering approach that mimics natural ravine stream features such as step-pools, cobble riffles, and native riparian buffers to reduce streambank erosion, preserve stream morphology, and improve water quality (see Figure 3.7). These practices are already employed in some areas of the watershed, such as along Hwy 67 in the Village of Fontana (see Figure 3.8). These practices can also be incorporated

[42] *SEWRPC Staff Memorandum,* Project Overview and Preliminary Finding Geneva Lake Watershed and Tributary Inventory, Geneva Lake, Walworth County, Wisconsin*, December 17, 2020*.

in residential areas by working with landscape architects to create designs that provide both aesthetics and function. This recommendation should be considered a high priority, particularly for steeply sloping tributaries in suburban areas.

➤ **Recommendation 3.20: Repair, reduce, or retrofit drain tile systems**

At a very minimum, damaged drain tile systems should be repaired to eliminate unintentional connections with surface water (e.g., blow outs, suck holes). As stated previously, these features dramatically increase the amount of soil and nutrients carried by drain tile networks to surface water. Natural surface hydrology should be restored by reducing, to the extent feasible, ineffective or unnecessary drain tile systems and/or retrofitting systems when needed. This recommendation should be considered a high priority. Specific measures that can be taken to accomplish this recommendation include:

- Encourage producers to identify and expeditiously repair drain tile network breaches. The most obvious locations are where water carried by drain tiles erupts to the surface or where surface runoff disappears into the Earth at unplanned locations.
- Discourage the use of surface inlets. Consider the profitability of closed depression areas drained by surface inlets and evaluate alternative water management or land use options.
- Investigate drainage patterns and available drain tile system maps to determine whether certain operational systems are no longer necessary. Remove or disconnect unneeded tile systems. If drain tile network maps are not available, drain tiles may often be identified using aerial imagery or unmanned aerial vehicles looking for lines of frost heave or reduced soil moisture in spring. Additionally, visual inspection along streams and ditches, especially in early spring when vegetation is low and runoff is generally greater, can reveal the drain tile outlets.
- Measure drain tile effluent total phosphorus concentrations and flow using a regular monitoring schedule (e.g., monthly or biweekly) to determine average total phosphorus loading and estimate proportion of total field phosphorus export. Whenever possible, measure tile discharge rates.
- Integrate in-line water level control devices into drain tile systems (see Figure 3.6). Lower water levels would be used to encourage drainage during spring and other stretches of excessively wet weather. Conversely, higher water levels can benefit crop yields during dry weather through

subirrigation. These control structures can reduce phosphorus and nitrogen loads by reducing tile flow volume as well as by promoting denitrification.[43]

Tributary-Specific Recommendations

The following subsection will address recommendations specific to individual tributaries from the Commission's planning efforts or from other recent planning efforts in the watershed.

Bigfoot Creek

Based on previous studies as well as data collected for this planning effort (see Section 2.4, "Water Quality"), the poor water quality conditions within Bigfoot Creek seem to stem from historical land use practices and chemical processes that naturally occur within degraded and invaded wetlands, such as those contributing to the Creek. Consequently, Commission staff recommend that wetland restoration project, including the removal of invasive cattail and establishment of native vegetation, should be prioritized to address these chronic water quality and pollutant loading issues. Given the extensive area of altered wetland contributing to the Creek, restoring this wetland will be a significant undertaking and will require planning work beyond the scope of this lake management plan.

➤ **Recommendation 3.21: Develop a wetland restoration plan for the Bigfoot Creek wetland**

Geneva Lake Conservancy is continuing their monitoring and research efforts on Bigfoot Creek in 2025 with an updated report and recommendations currently being prepared by Resource Environmental Solutions. Their initial findings, like previous studies, point to recommending an engineered wetland to filter pollutants. However, emerging RES recommendations that emphasize the use of native vegetation for pollutant filtration in engineered wetlands may present new approaches to addressing water quality concerns in Bigfoot Creek in the coming years. The GLC and other partners should continue to develop a site management plan to restore the wetland and improve water quality conditions within the Creek and Lake. Given the importance of the Creek for the Lake's phosphorus budget, this recommendation is a high priority.

Common approaches to managing invasive cattail (*Typha angustifolia* and *Typha x glauca*) populations, as observed in the Bigfoot Creek wetland, include manual or mechanical removal of cattail to encourage

[43] *For a thorough literature review on phosphorus dynamics with drain tiles, see* J. Moore, Literature Review: Tile Drainage and Phosphorus Losses from Agricultural Land, *Lake Champlain Basin Program*, 2016

the reestablishment of native vegetation. This may involve cutting stems or scraping cattail stands followed by the removal of cut or scaped material. Prescribed fire presents another option for removing standing dead cattail and plant biomass if burning treatments are applied during periods when fuel in the wetland is dry enough (typically winter, early spring or fall in Wisconsin). Then restoring degraded wetlands, treated areas should be seeded with a native wetland plant seed mix following the removal of cattail and other invasive emergent plant species. Removal of cattail should facilitate the growth of these native species by reducing competition for space, light, nutrients and other essential plant resources within the wetland. Diversification of wetland vegetation can help improve wetland ecosystem function, water quality and habitat for aquatic and terrestrial wildlife. Attention should be given to the timing of habitat restoration, as the removal of cattail in wetlands with extensive invasions can be especially disruptive to nesting and breeding marsh birds.

Abbey Springs Creek

➤ **Recommendation 3.22: Enhance buffer along stream in golf course**

Sections of the Creek run through the golf course where there are little to no buffers between the golf greens and the stream banks. Enhancing the riparian buffer for areas withing the golf course will help to mitigate the amount of runoff reaches not only the creek but also the Lake. This recommendation is a medium priority due to the high phosphorus concentrations in the stream.

Southwick Creek

➤ **Recommendation 3.23: In Southwick Creek, conduct channel naturalization along the ditch parallelling STH 67**

The ditching and channelization of the Creek likely significantly reduced the stream's ability to detain and cleanse floodwater, in turn increasing the amount of sediment delivered to the Lake and increasing flood peaks in downstream areas. It is recommended with a medium priority that this portion of the creek be restored to a meandering channel through the wetland which would result in some if not all of the benefits below (see Figure 3.9):

- Increases local conveyance capacity for a given flood flow, lowering flood peaks at the water plant
- Allows floodwater to be detained, reducing downstream peak flows and flood elevations
- Reduces in-channel velocities in portions of the channel, reducing streambank erosion and increasing habitat diversity

- Allows fine-grained sediment and nutrients suspended with floodwater to settle in the relatively still water of floodplains
- Helps sustain higher streamflow during fair weather
- Increases channel length and improves channel form, in turn improving the amount of habitat that can host available desirable sportfish such as trout
- Produces aquatic organism refuge areas for high-flow events and improves access to riparian wetlands favored by lithophilic lake-run spawning fish such as northern pike

Covenant Harbor Creek

➤ **Recommendation 3.24: Implement storm water improvements to the Wilkins Trust storm water retention basin on the Covenant Harbor property**

The October 16, 2020 report done by Ruekert & Mielke proposed a variety of project to reach 3 main goals for the basin and its surrounding area:[44]

- Protect and preserve as many existing trees and high-quality habitat as possible.
- Reduce the proposed disturbed and detention basin storage area to at or below the 0.5 acres in the agreement
- Improve water quality prior to discharge into Geneva Lake

This recommendation is a medium priority. Additionally, the Commission provided the following suggestions for the Creek in their 2020 study:[45]

- Preserve and possibly enhance channel form and floodplain function in the low gradient stream reach that crosses the 17.9-acre parcel immediately upstream of State Highway 50 and Forest Street. Portions of the stream in this area are likely ditched and could be enhanced through channel naturalization (e.g., remeandering).
- Explore opportunities to detain water in extreme headwater reaches not investigated as part of this inventory.
- Use approaches such as ditch turn-outs, ditch checks, and regenerative stormwater conveyance principles to slow and filter runoff before it reaches the main stem of the stream.
- As practical, employ regenerative stormwater conveyance principles to restore floodplain functions in eroded, high-gradient stream reaches.

[44] Covenant Harbor Storm Water Detention Basin Analysis. *Ruekert & Mielke. October 16, 2020.*
[45] *Project Overview and Preliminary Findings, Geneva Lake Watershed and Tribtary Inventor Geneva Lake, Walworth Count, Wisconsin. December 17, 2020.*

- Disconnect residential drain tiles that lead to and discharge directly into the stream channel. Promote practices that increase stormwater infiltration to reduce volume and rate of water entering stream channels. Since many residential developments in this tributary's watershed were constructed before WDNR stormwater management laws become effective (prior to 1990), and residential land use comprises a high proportion of the total land uses within this subbasin, a great opportunity exists to reduce stormwater runoff volume and intensity by implementing residential green infrastructure practices.

Potawatomi and Van Slyke Creeks

➤ **Recommendation 3.25: Conduct storm water flood mitigation in STH 67 Pond**

This recommendation is a <u>low priority</u>. The pond at the subdivision entrance for Whitetail ridge regularly floods and exceeds its banks during large storm events. Ruekert & Mielke's 2020-2021 study[46] recommends the following to prevent future flooding of the STH 67 Pond:

- Review WisDOT STH 67 storm sewer plans
- Add material to east side of the existing pond to increase storage volume
- Ass new storm water retention basin on eastern portion of the golf driving range

  Divert runoff to the existing depression area on private property on north side of STH 67, north of the pond

➤ **Recommendation 3.26: Restore Potawatomi Creek channel where it flows through Bigfoot Country Club**

This recommendation is a <u>low priority</u>. Sections of the Potawatomi Creek flow through the Bigfoot Country Club. Areas of the stream bank have experienced significant erosion and caused sediment to be transported downstream and end up in the Abbey Marina. Currently, the golf course lawn is maintained up to the edge of the creek. Ruekert & Mielke's 2020-2021 study[47] recommend the following for this portion of the Potawatomi Creek:

- Restore stream banks and reduce water velocity by installing in-channel structured
- Plant native vegetation buffers along the stream banks

➤ **Recommendation 3.27: Restore floodplain connectivity in forested area of lower Van Slyke Creek**

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[46] *Potawatomi Creek and Van Slyke Creek Watershed Study 2020-2021. Ruekert & Mielke. Prepared for Fontana-on-Geneva-Lake.*
[47] *Ibid.*

This recommendation is a low priority. Portions of lower Van Slyke Creek are isolated from the floodplain due a bermed pond, undersized culverts at road crossings and significant amounts of invasive species. Some strategies for reconnecting the floodplain, outlined in Ruekert & Mielke's 2020-2021 study[48] include:

- Remove or restore abandoned walking trail so it no longer impedes floodplain connectivity
- Open the berm of the stormwater pond
- Re-meander creek channel, including restoration of historical channel south of East Dewey Avenue.
- Replace culverts at road crosses with appropriately sized culverts or structures
- Remove invasive species and reintroduce native vegetation

➤ **Recommendation 3.28: Restore wetland and conduct ravine stabilization on Potawatomi Creek channel near South Lakeshore Drive**

This recommendation is a low priority. Areas of the wooded wetlands and stream channel have become severely eroded due to high intensity rainfall events. Channel banks have become highly eroded leading to steep and unstable ravines. The erosion has caused sediment accumulation within the wetland. Ruekert & Mielke's 2020-2021 study recommends:

- Restoration of eroded ravine slopes
- Construct in-channel structures to reduce stream velocity
- Restore wetland by removing sediment accumulations and re-introducing native vegetation
- Remove nonnative species that have taken over areas of the wetland

➤ **Recommendation 3.29: Redirect stormwater flow away from directly inputting into a Potawatomi Creek tributary**

This recommendation is a medium priority. A ditch and constructed stormwater basin along STH 67 in the Fontana Fen collect stormwater runoff and feeds directly into a tributary of Potawatomi Creek. Ruekert & Mielke's 2020-2021 study recommends:[49]

- Reconstruct gravel driveway into the fen so it acts like a weir, increasing storage capacity
- Expand stormwater basin to have a higher capacity before it empties into the culvert under STH 67
- Meader the creek channel and construct connected floodplain to store stormwater during flood events

[48] *Ibid.*
[49] *Ibid.*

- Construct and appropriate water control structure at the confluence of the Potawatomi tributary to reduce creek velocity and reduce erosion

➤ Recommendation 3.30: Remediate Main Street Ditch from Dewey to STH 67

This recommendation is a low priority. The portion of the creek along Main Street that connects to the fen via a culvert under Dewey Avenue is extremely channelized and overgrown with invasive species. Ruekert & Mielke's 2020-2021 study[50] recommends:

- Remove invasive species and replace them with native vegetation
- Re-meander stream channel further away from the street to prevent continued erosion of the road bed
- Create connections to the fen to restore historic hydraulic regime

➤ Recommendation 3.31: Restore middle reach of Van Slyke Creek at location of historical millpond

This recommendation is a low priority. A mill pond was located in the middle reach of Van slyke Creek during the late 1800s to the early 1900s causing there to be extensive disturbance to that area of the creek. There are berms, ditches, debris, and invasive species throughout that area. Ruekert & Mielke's 2020-2021 study[51] recommends:

- Removal of invasive species and debris, then restore with native vegetation
- Consider removing eastern section of the millpond embankment to allow the creek to use the floodplain
- Enhance existing structure to reduce side and head cutting of banks
- Replace culvert under the bridge with a more suitable structure

➤ Recommendation 3.32: Remediate Main Street ditch to allow for better flow and fish passage

This recommendation is a low priority. The upper reaches of Van Slyke Creek have limited fish passage due to stormwater structure in the Main Street ditch and under Main Street. In some areas the stream has become channelized resulting in high velocity flows. Ruekert & Mielke's 2020-2021 study[52] recommends:

- Restore Main Street ditch to a more natural condition
- Move ditch further from street to reduce roadbed erosion

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[50] *Ibid.*
[51] *Ibid.*
[52] *Ibid.*

- Improve confluence of ditch and main channel to prevent head cutting along Main Street
- Daylight stream crossing under Main Street to improve flow and fish passage, potentially even secondary channel

➤ **Recommendation 3.33: Redirect stormwater flow to prevent runoff directly inputting into a Van slyke Creek Tributary near lower portion of the Stewart Property at the north side of Main Street**

This recommendation is a medium priority. Significant amounts of sediment and uncontrolled stormwater runoff, some from the residential lot nearby, flow into the store sewer under Main Street E?W which drains into a drainage way connecting to Van Slyke Creek. Ruekert & Mielke's 2020-2021 study[53] recommends:

- Construct new meandering channel and storm water detention on Stewart Property to: reduce peak flows, settle out sediment and redirect flow from Main Street N/S ditch to existing stormwater sewer crossing under Main Street E/W
- Improve/naturalize lower drainage way connecting to Van Slyke Creek with appropriate structures to control water flow
- Remove invasive species and introduce native vegetation

➤ **Recommendation 3.34: Implement potential projects outlined in the 2009 Potawatomi/Van Slyke Report prepared for Fontana-on-Geneva-Lake.**

The October 2009 report outlines 19 potential projects that could be completed in the Potawatomi and Van Slyke Creeks watersheds. Ten of those projects are specific to Potawatomi Creek, 7 are specifically for the Van Slyke creek watershed and two projects are overarching recommendations. This recommendation is a low priority.

Gardens Creek

➤ **Recommendation 3.35: Consider saturated buffers in agricultural lands to encourage denitrification.**

Saturated buffers, unlike ordinary riparian buffers, capture and treat water from tile drainage. A saturated buffer has a control structure that redirects flow from a main tile line through a lateral distribution line into the buffer. Once within the buffer soils, the water redirected from the tile percolates deeper into the soil or gets taken up by vegetation. In its study at Bear Creek in Iowa, the Leopold

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[53] *Ibid.*

Center for Sustainable Agriculture at Iowa State University found that the use of a saturated buffer reduced annual nitrate loads by about 55 percent. However, the evidence for phosphorus removal through saturated buffers is not well established.[54]

Bioreactors are another method for capturing and treating tile drainage water. Unlike saturated buffers, which redirect nutrients deeper into soil or into vegetation, bioreactors remove nitrates by promoting a process called denitrification, by which nitrate is predominantly converted to inert nitrogen gas. Bioreactors provide a carbon source, such as wood chips, for the bacteria to fuel this conversion. As with saturated buffers, there is less consensus that bioreactors are effective for reducing phosphorus loads.[55] Implementing saturated buffers and bioreactors to reduce nitrogen from tile drainage water should be considered a low priority.

Communication, Education, and Outreach

Identifying, communicating with, and supporting willing partners in the watershed is necessary to implement the BMPs listed above. The following suggestions are provided to enhance communication, education, and outreach regarding nonpoint source BMPs. All are assigned a high priority.

- Host or sponsor educational workshops and tours, demonstration projects, and information exchange forums focusing on emerging BMPs.
- Engage, and possibly subsidize, agricultural producers to implement practices that improve water quality. Provide information, technical support, tools and equipment, and financial support.
- Promote engagement by the farming community in decision-making and equip farmers with monitoring tools and methods.
- Target action-oriented messages about water quality and conservation practices to key groups.
- Continue to produce and distribute newsletters, exhibits, fact sheets, and/or web content to improve communication around these issues.

[54] *For a thorough literature review on phosphorus dynamics with drain tiles, see* J. Moore, Literature Review: Tile Drainage and Phosphorus Losses from Agricultural Land, *Lake Champlain Basin Program*, 2016
[55] *Ibid.*

3.5 SHORELINE

Maintaining shorelines and streambanks can reduce sediment and phosphorus loading associated with erosion and/or runoff into the Lake and its tributaries. Shoreline and riparian gardens can also provide essential wildlife habitat as well as add beauty to a lake residence.

- **Recommendation 3.36: Incorporate native vegetation into shoreline protection measures**

  Much of Geneva Lake's shoreline is protected by "hard" (wood, metal, or concrete) manmade structures of riprap or bulkhead. Such structures are highly effective methods of protecting against the erosive nature of wave action and these structures need to be adequately maintained, particularly given the sizeable wind and boat-induced waves on Geneva Lake. However, shoreline protection needs to also protect against sediment and nutrient runoff. Incorporating native vegetation into and behind riprap can shore up these protective measures while also providing pollutant reduction and wildlife benefits (see Figure 3.10). Consequently, incorporating native vegetation with hard shoreline protection is highly recommended.

- **Recommendation 3.37: Support current programs, such as Conservation@Home and Keep It Blue, to promote native plantings and shoreline gardens and reduce phosphorus loading**

  The Geneva Lake Conservancy currently runs and sponsors conservation programs that encourage homeowners and businesses to conduct projects that benefit the Lake and its watershed. These programs, such as Conservation@Home, Conservation@Work, Conservation@School, and Conservation@HOA, educate and recognize home owners, businesses, schools, and homeowner associations for environmentally conscious choices in their landscaping.[56] Since beginning these programs in 2020, the GLC has visited over 300 properties to encourage natural landscaping that promotes native habitats, water infiltration, and runoff reduction.[57] They also promote the reduction of money and energy spent on grass care and more. This recommendation is a high priority.

  The GLC also supports the Keep It Blue program, which is a pledge that homeowners can make to reduce fertilizer and pesticide runoff to Geneva Lake (see Figure 3.11).[58] As of 2025, 160 property owners

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[56] *For more information on these programs, see the Geneva Lake Conservancy webpage about these programs at the following link: https://www.genevalakeconservancy.org/programs.*
[57] *Personal communication between GLC and Commission staff, October 2025.*
[58] *For more information on the Keep It Blue program, see the following link: https://www.genevalakeconservancy.org/keep-it-blue.*

around Geneva Lake have signed the pledge.[59] When homeowners sign the pledge, they commit to the following:

- Eliminate the use of fertilizer and pesticides on their property
- Prevent leaves from entering the waterways (lakes and their tributaries)
- Stop soil erosion by planting native trees and plants, especially along the Lake and its tributaries
- Prevent pet waste, soaps, and harmful chemicals from entering any waterway
- Educate neighbors and friends on the importance of the above

Additionally, the GLC provides a flyer for the Keep It Blue program with the following recommendations:[60]

- Reduce salt on icy surfaces.
- Properly maintain septic systems
- Water wisely
- Build healthy soil: adding organic grass clippings and leaves to soil for better water and nutrient retention, while reminding people to keep leaves out of the waterways
- Install native planting buffer strips
- Choose porous surfaces over pavement and cement
- Capture roof runoff with a rain barrel or a rain garden
- Use silt fencing when building or disturbing the soil
- Give your lawn back to nature: plant native to help keep chemicals out, conserve water, and attract pollinators.

Continuing and expanding participation in this program is recommended as a high priority.

➤ Recommendation 3.38: Continue to sponsor WDNR Healthy Lakes & Rivers projects

The WDNR Healthy Lakes and Rivers grant program provides funding for shoreline and nearshore projects such as fish sticks, rain gardens, native plantings, rock infiltration and diversion practices. These

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[59] *Personal communication between GLC and Commission staff, October 2025.*
[60] *Ibid.*

practices help to protect and preserve a lake's shoreline and nearshore area. Potentially suitable areas for fish habit projects are identified in Figure 3.2. This recommendation is a high priority.

- **Recommendation 3.39: Collaborate with gardening groups to sponsor demonstration days and recognition for shoreline gardens, rain gardens, and other ecologically beneficial plantings**

Several non-profits focused on gardening exist in the Geneva Lake watershed, such as the Fontana Garden Club and the Lake Geneva Garden Club, as well as local publications that feature local gardens, such as *At the Lake: Geneva Lake Area Magazine*.[61,62] Lake stakeholders should collaborate with these organizations to feature beautiful shoreline and rain gardens around the Lake to feature their aesthetics and functionality in protecting the Lake's water quality. Ideas to help feature these gardens include demonstration days with local landscape architects to show how to design and plant these gardens, featured articles in local publications highlighting new shoreline garden projects, and awards for best new garden. This recommendation should be considered a medium priority.

- **Recommendation 3.40: Compile list of local contractors and landscape architects that support native plantings and shoreline practices**

Many property owners may seek to conduct projects that can have impacts on the watershed and Lake health, such as riparian landscaping. Lake managers should compile a list of contractors that construct work in environmentally conscious ways or offer services that aid in protecting and restoring the environment. This recommendation is a medium priority.

- **Recommendation 3.41: Reduce refracted wave energy**

Shorelines armored with concrete walls, wood, and other straight and hard materials tend to reflect wave energy back into the Lake. This refracted energy eventually reaches another shoreline, where it is either absorbed or again refracted back into the Lake. Such conditions can magnify the erosive power of waves. Many actions can be taken to reduce wave energy refraction. Examples include using irregular materials and surfaces that help absorb and dissipate wave energy, planting emergent or floating leaf plants to dissipate energy before it reaches the shoreline, and substituting hard shoreline armor for plants and woody structure. Perhaps the most practical way of approaching this issue is to require wave-

[61] *https://www.facebook.com/FontanaGardenClub/*
[62] *https://atthelakemagazine.com/*

energy absorbing features in new or repaired shoreline protection plans. This recommendation is a low priority.

3.6 AQUATIC PLANTS

Any aquatic plant management activities need to involve more than a short-term fix. Balances have to be struck between human recreational (and other) uses and the long-term ecological health of the lake. Considerations have to be given to not only controlling those volumes of plants and algae that deter recreational use, but also to the existence of invasive species like EWM, the long-term stability of the native aquatic plant community, the role of the plant community in the Lake's water quality, and the importance of keeping a balance between aquatic plants and algae – since both compete for the same nutrients, elimination of one will result in the over-abundance of the other. It is also important to remember that native aquatic plants form a foundational part of a lake ecosystem; large-scale removal of native plants that may be perceived as a nuisance (e.g., white water lilies) should be avoided when developing plans for aquatic plant management.

At this time, Geneva Lake has no large-scale management of aquatic plants. Some individual riparian property owners and marinas conduct small scale management of aquatic plants. This section summarizes the information and recommendations needed to manage and monitor both native and invasive aquatic plant populations on a large scale in the Lake. The recommendations provided focus on those that can be implemented by key Lake management groups such as the GLC and GLEA.

- **Recommendation 4.1: Conduct yearly surveys of starry stonewort populations to examine spread and population size**

  While whole lake point-intercept aquatic plant surveys and sub-point-intercept surveys provide detailed quantitative data on aquatic plant populations, they can be costly and time consuming. For the monitoring on the non-native SSW, other survey techniques are recommended to be used on a yearly basis that are most cost and time – effective (see Figure 3.2 for recommended monitoring sites). This recommendation is a high priority.

- **Recommendation 4.2: Conduct whole-lake aquatic plant point-intercept surveys once every 5-7 years**

At this time, Geneva Lake does not employ any large scale coordinated efforts for aquatic plant management. It is recommended that unless there is a desire to conduct large scale management of aquatic plants or there is a concern about the population on nonnative or nuisance level growth of aquatic plants, whole lake aquatic plant surveys should be conducted once every 5-7 years. This recommendation is a medium priority.

- **Recommendation 4.3: DASH could be employed by individuals to provide relief on nuisance native and nonnative plants around piers.**

If an individual landowner chooses to implement DASH, the activity is typically confined to the same width of 30 feet of shoreline and cannot extend more than 100 feet into the Lake. Some individuals and entities on the lake already utilize DASH for aquatic plant control in nearshore areas by their property. However, given how costly DASH can be and how widespread invasive aquatic plants are across the Lake, DASH is not considered a viable control option for managing AIS throughout Geneva Lake. Any use of DASH requires an NR 109 permit. This recommendation is a low priority.

- **Recommendation 4.4: Monitor algal abundance and sample algae toxins during suspected algal bloom conditions**

This effort should focus on monitoring chlorophyll-a, as was described in water quality monitoring recommendations. If large amounts of suspended or floating algae are observed (e.g., "pea soup" green water), algal samples should be collected to allow algal types, particularly toxic strains, to be identified and better inform healthy use of the Lake. Given that there have been several observations of algal blooms, including potential cyanobacterial blooms, on the Lake within the past few years, this recommendation should be assigned a high priority.

- **Recommendation 4.5: Warn residents not to enter the water in the event of an algal bloom**

Methods to rapidly communicate unhealthful water conditions not conducive to body contact should be developed. Lake managers could consider installing advisory signage at the boat launch to inform Lake users of the possibility of algal blooms.[63] Significant suspected blue-green algal blooms can be reported to the WDNR at DNRHABS@wisconsin.gov. This recommendation should be assigned a high priority.

[63] *The WDNR blue-green algae webpage has example signage: www.dnr.wisconsin.gov/topic/lakes/bluegreenalgae*

- **Recommendation 4.6: Encourage a healthy aquatic plant community to compete with algal growth**

  Aquatic plants utilize phosphorus in the water column, limiting its availability for algae and subsequently limiting algal abundance. Thus, a healthy aquatic plant community is an essential component of improving water quality and reducing undesirable algae in the Lake. This recommendation should be assigned a high priority.

- **Recommendation 4.7: Consider acquiring small aquatic plant harvesters to address nuisance growth in highly trafficked areas**

  The aquatic plant community on Geneva Lake does not warrant widespread management using large mechanical harvesters. However, several groups, including homeowner associations, marinas, and municipalities, practice small-scale aquatic plant management to address nuisance plant growth in highly trafficked areas. In some of these instances, chemical treatment is the preferred aquatic plant control method. While this is a viable method for addressing the plant growth, chemical treatment can negatively impact sensitive non-target species and repeated use over time can lead to inherited genetic resistance to chemical treatment. Several manufacturers produce small aquatic plant harvesters that are relatively inexpensive and can maneuver in tight spaces to target nuisance plant growth in these areas. A benefit of aquatic plant harvesting is that the removal of aquatic plants from the Lake also reduces the phosphorus load within the Lake. Acquisition of this equipment may be partially funded through the WDNR Recreational Boating Facilities grant program.[64] This recommendation should be considered a medium priority.

3.7 INVASIVE SPECIES

- **Recommendation 4.8: Continue participation in the Clean Boats, Clean Waters program**

  Clean Boats, Clean Waters is a WDNR program that proactively encourages Lake users to clean boats and equipment before launching and using them in a lake. The GLEA, municipalities, and other partners have collaborated to operate this program at all public launches on the lake (see Figure 3.2).[65] These efforts are even more critical to maintain given that Geneva Lake is the only inland lake in Wisconsin with a verified population of the invasive quagga mussel. This recommendation is a high priority.

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[64] *For more information about this grant program, see https://dnr.wisconsin.gov/aid/RBF.html.*

[65] *Further information about Clean Boats Clean Waters can be found on the WDNR website at: dnr.wi.gov/lakes/cbcw.*

- **Recommendation 4.9: Fundraise and work with local municipalities to maintain AIS decontamination equipment at all public launches**

  Decontamination equipment is a useful tool to help stop the spread of invasive species. Particularly in light of the recent discovery of the quagga mussel in Geneva Lake, it is imperative that public launches are prioritized for decontamination equipment. Decontamination equipment can range from simple brushes and garbage bins to full decontamination trailers like the CD3 trailer currently utilized at some of the launches around the Lake (see Figure 3.12). This recommendation is a medium priority.

- **Recommendation 4.10: Use mixture of whole-lake aquatic plant surveys and targeted surveys at launches to monitor AIS**

  Due to the recent establishment of starry stonewort within Geneva Lake, the Lake has been the subject of intense monitoring of the aquatic plant community with nearly annual whole-lake point-intercept surveys funded by the GLEA. Although these initial surveys were required to understand both the scale of the starry stonewort population as well as the efficacy of management techniques, the population has now been well-characterized and active management of the population in the main lake is not recommended. Consequently, whole-lake surveys to monitor this population should be conducted less frequently and the funding could be spent on other lake management issues. Instead, the GLEA and other partners could more frequently conduct meander surveys and/or sub-point-intercept surveys near the public and private launches to monitor for any novel invasions as well as spread of starry stonewort to new locations on the Lake (see Figure 3.2). This recommendation should be considered a high priority.

- **Recommendation 4.11: Provide signage and education to properties with private boat launches and lake access to ensure the spread of invasive species is mitigated.**

  While Geneva Lake boasts many launches and lake access points that are open to the public, it should not be overlooked that the Lake also has numerous private launches. These private launches should be targeted for invasive species education campaigns. The owners of these private launches should be educated on proper boating decontamination as well as be educated on where to find and how to post appropriate signage at their launch. This recommendation should be considered a high priority.

- **Recommendation 4.12: Place advisory buoys surrounding the starry stonewort population to warn boaters of its presence and to limit activities in the colony areas that could increase its spread.**

  Limit or prohibit mooring and wakes in areas with invasive species. Intense boating activities in shallow areas can cause disturbance of the aquatic plants and fragment them. Additionally, mooring and the pulling up of anchors can uproot invasive plants. Activities that can cause invasive plant species to become uprooted and subsequently spread should be limited in SSW colony areas (see Figure 3.2). This recommendation should be considered a medium priority.

3.8 FISHERIES AND WILDLIFE

Biological communities are a direct measure of waterbody health—an indicator of the ability of a waterbody to support aquatic life. Geneva Lake is a popular fishing destination for anglers during all seasons of the year. Additionally, the watershed supports numerous wildlife species in its varied upland, wetland, and aquatic habitats. Fish and wildlife depend upon the health of the Lake, its tributaries, and the environmental corridors found throughout the watershed. The presence of fish and wildlife increases the Lake's recreational use, aesthetic appeal, overall enjoyment by humans, and the functionality of the Lake as an ecosystem. To enhance fish and wildlife quality and abundance within the Geneva Lake watershed, the following recommendations are made.

- **Recommendation 5.1: Continue periodic monitoring of zooplankton, phytoplankton and rotifer populations in the Lake**

  As mentioned in Chapter 2, phytoplankton, rotifers and zooplankton serve as the foundation of the trophic cascade, or food web, in lake and river systems. Monitoring populations of these organisms can track the health of the lake and indicate when the lake's health is declining or improving. This recommendation is a low priority.

- **Recommendation 5.2: Continue monitoring of nearshore fishery populations in the Lake**

  Nearshore fishery surveys conducted on Geneva Lake help to fill gaps that WDNR fishery surveys are not able to conduct due to staffing, funding, or priority limitations. These surveys help to examine how the nearshore fish populations are changing and potentially being affected by wave action and shoreline development. WDNR and Commission staff recommend the continuation of these surveys to examine changes over time in fish populations. This recommendation is a high priority.

- **Recommendation 5.3: Collaborate with WDNR to survey and manage cisco population**

As discussed in Section 2.7, "Fisheries and Aquatic Animals," WDNR fishery biologists have identified cisco as one of the most important fish species in Geneva Lake as this species provides the foundation for the Lake's productive sport fishery. Although the Lake still supports cisco and has suitable oxythermal habitat, warming temperatures and increased nutrient enrichment may threaten this species as these factors have contributed to the loss of this species in several other two-story lakes in southeastern Wisconsin.[66] Lake managers should collaborate with the WDNR to support this species and consider innovative approaches, such as introducing genetic strains resilient to warming temperatures and/or artificially supplementing dissolved oxygen concentrations during stressful periods, to maintain the cisco population in the Lake. This recommendation is a medium priority.

- **Recommendation 5.4: Protect nearshore aquatic plant communities that provide habitat to the nearshore fishery**

As discussed in Section 2.7, "Fisheries and Aquatic Animals," Geneva Lake has lost several sensitive species of fish due in part to the lack of nearshore fish habitat, such as coarse woody structure and aquatic plant beds. Nearshore aquatic plants beds and other ecologically sensitive areas should be protected to the extent feasible (see Figure 3.2). Riparian property owners should be educated about the benefits that nearshore aquatic plants give to the Lake's fishery and overall lake health. This recommendation is a medium priority.

- **Recommendation 5.5: Introduce coarse and large woody habitat to areas to help restore nearshore fishery in the Lake.**

Coarse woody habitat in the nearshore area provides many ecosystem benefits. In particular it provides habitat for juvenile and small fishes. This habitat is crucial for the successful recruitment of fishes in the Lake. Commission staff identified multiple stretches of less developed shoreline along the Lake where installation of coarse woody habitat near the shoreline would not impact navigation or access to private piers (see Figure 3.2). The introduction of coarse woody habitat may require a permit and riparian property owners should reach out to their local WDNR Biologist to discuss a tree drop to create coarse woody habitat. This recommendation is a medium priority.

[66] *The WDNR intends to survey Geneva Lake for cisco soon after the publication of this management plan.*

- **Recommendation 5.6: Identify and remove instream barriers to passage of fish and other aquatic organisms.**

Even ephemeral streams, which only flow seasonally, can provide fish passage and two-way access to spawning and nursery grounds. Potawatomi and Van Slyke Creeks are life-cycle critical resources to some fish species such as trout and are a favored resource for many. For example, temporarily flooded grassy areas can be favored spawning areas for northern pike. Fish species known or likely to use the tributaries include white suckers, walleye pike, northern pike, and other forage fish.

Fish passage barriers are often categorized by scale. Small scale barriers include debris jams, sediment and railroad ballast accumulations, and overgrowth of invasive plants. Such barriers are commonly not recognized as problems but can significantly affect fishery vitality. Large scale barriers include dams and culverts that are perched, too narrow, or too long. These barriers vary greatly in their ease of removal. BMPs include prioritization of barrier removal along a single stream, with highest habitat benefits and highest ease of removal given the highest rank for remediation. Ozaukee County's Fish Passage Program is highly developed and is a good information resource.[67] Removing fish passage barriers in Geneva Lake tributaries should be considered a low priority. Fish passage projects often require frequent communication and active collaboration with private land owners, municipalities, and highway departments.

- **Recommendation 5.7: Current fishing practices and ordinances should continue to be enforced**

As the current fishery appears healthy, this requires no direct change and would therefore be a medium priority. Prioritization should be reconsidered if the fishery characteristics or recreational uses tangibly change. This recommendation is a high priority.

3.9 RECREATIONAL USE AND FACILITIES

Geneva Lake supports diverse recreational activities, such as swimming, kayaking, water-skiing, cruising, sailing, wake sports, and fishing. Maintaining the Lake's ability to provide safe, high quality recreational pursuits is a priority issue. In support of this goal, the following recommendations are made:

- **Recommendation 6.1: Collaborate with municipalities to develop, and post at launches, recreational use recommendations for the lake**

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[67] *See website at www.co.ozaukee.wi.us/619/Fish-Passage.*

Signage at launches could outline not only local ordinances and boat regulations but also contain information about boating safety and courtesy. Signage should be clearly posted and maintained. Consider posting signage in more than one language if posted in an area with diverse patrons. This recommendation is a high priority.

➤ **Recommendation 6.2: Encourage safe boating practices and boating pressure on the Lake**

Use conflicts, safety concerns, and environmental degradation were presented as issues of concern during the preparation of this plan, if boat densities increase to undesirable levels in the future, boating ordinances and regulations should be reviewed, and if necessary, modified. Such ordinances and regulations should be conscientiously enforced to help reduce the potential for problems related to boat overcrowding during periods of peak boat traffic. Since problems are not known to currently exist, but because boat densities are relatively high during peak periods, this should be considered a medium priority issue.

➤ **Recommendation 6.3: Implement an education campaign with boat rental companies and marinas to educate visiting boaters on rules and recommendations**

In addition to the public launches, many boaters access the lake through boat rental companies and marinas, which provide boats owned by the company or provide a valet service to prepare boats owned by the customer. It is recommended that boaters access the Lake through these means be provided with the same educational materials regarding boating ordinances, safety tips, and practices to reduce the spread of AIS as boaters accessing through public launches. This recommendation is a high priority.

➤ **Recommendation 6.4: Consider conducting regular online surveys of recreational users to gather feedback about recreating on the Lake**

Such monitoring provides valuable feedback as to the effectiveness of management actions and helps to communicate lessons learned. The most recent survey of lake users in 2023 helped to guide the development of this plan. Educating stakeholders in lake management efforts and receiving feedback on their concerns encourages stakeholders to be engaged in issues surrounding the lake. This recommendation should be considered a low priority.

➤ **Recommendation 6.5: Track and maintain shoreline and rock buoys stationed across the Lake**

Keeping an updated list of buoys with their coordinates can assist in identifying buoys that need to be replaced as well as buoys that have moved from their set position. This recommendation is a high priority.

➤ **Recommendation 6.6: Maintain and enhance fishing by protecting and improving aquatic habitat and ensuring the fish community remains viable**

Lake managers should consider designating sensitive ecological areas via establishing extended slow-no-wake zones to protect existing aquatic plant habitat, particularly where sensitive fish species have been observed in the Lake. Other means to achieve this recommendation are by implementing the aquatic wildlife recommendations provided in Section 3.8, "Fisheries and Wildlife." This is a medium priority issue.

➤ **Recommendation 6.7: Consider increasing launch fees during peak use periods**

Demand for power boating on Geneva Lake may exceed optimal use during weekends and holidays. Common economic theory suggests that demand can be reduced if costs increase. Launch fees can include the basic price paid to launch a boat and other factors such as convenience.[68] Certain changes can be made that both benefit the long-term health of the Lake and may place negative pressure on demand. Examples of such changes include the following:

- Maintain motorized boat launch fees at the maximum permissible rate during weekends and holidays. Consider launch surcharges (such as the following), particularly on weekends and holidays, to adjust fees:
    - Twenty per cent surcharge for launch sites with toilet facilities. Potentially also apply to weekday rates to enhance revenue available for providing weekend/holiday launch attendants.
    - Large boat surcharges. An attendant would need to be on site for effective application. Allowable large boat surcharges are 30 percent for boats 20 to 26 feet long, and 60 percent for boats longer than 26 feet.
    - Have an attendant on duty during all summer weekends and holidays. The attendant's primary duty would be to implement Clean Boats/Clean Waters watercraft inspections and distribute

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[68]*See* Wisconsin Administrative Code *NR 1, Natural Resources Board Policies, for more information. NR 1.91, Public Boating Access Standards, describes permissible fee structures.*

literature to help Lake users understand invasive species issues. A surcharge of 20 percent may be charged when an attendant is on duty, and the attendant can also be responsible for launch surcharges for large boats.

- Increasing launch fees is assigned an overall medium priority, the implementation of which is dictated by the desires of the boat launch owner and the needs and perceptions of Lake users.

➤ Recommendation 6.8: Take action to reduce conditions leading to powerboat-induced shoreline erosion

This recommendation is a medium priority. A number of ordinances are already enforced that are designed to protect shoreline and shallow areas around the Lake. To help minimize the ecological and environmental impacts of large boats and enhanced wake operations, Lake stakeholders should encourage boat operators to take the following actions:

- Novice boaters should be instructed on proper boating etiquette as well as how to operate a large vessel to minimize its wake impact on the shore and other boats.

- Operate boats at speeds equal to or less than slow-no-wake in water less than 10 feet deep.

- Avoid turning boats in tight circles as they increase wave height and frequency.

- Boaters engaged in wake sports and other boats with large wave impacts should be directed to waters over 500 feet from shore and at least 30 feet deep to minimize large wave impacts to shoreline and lake bottom sediments (see Figure 3.13).

- Seek deeper water to minimize contact with vegetation. Encourage boats to operate outside EWM or SSW control areas to reduce fragmentation and spread of these invasive species.

- Adopt practices to stop the movement or transport of aquatic invasive species by draining water from, drying, and decontaminating all parts of the boat that come into contact with water.

3.10 LAKE MANAGEMENT STRUCTURE AND PLAN IMPLEMENTATION

A primary interest among the partners involved in the development of the Geneva Lake comprehensive plan update has been in the structure of organizations involved in lake management. The following section will describe the current roles and responsibilities assumed by various organizations involved in lake management and will provide alternative structures and pathways for lake management and governance.

Water Alliance for Preserving Geneva Lake

In 2019, the Geneva Lake Task Force, which later became the Water Alliance for Preserving Geneva Lake, was formed by the Geneva Lake Conservancy to bring together all the public and private organizations involved with the lake to address growing stakeholder concerns, including starry stonewort, water quality, and boating issues. It was formed to help coordinate activities between multiple lake stakeholders, including the GLC, GLEA, GLA, lake municipalities Walworth County, WDNR, University of Wisconsin – Whitewater, the Commission, and other interested citizens and organizations.[1] It has been divided into subcommittees (Phosphorus, Invasive Species and Agriculture/Septic Issues) to address growing problems. The group met every other month until 2022 to discuss resources, funding, problem-solving, and other lake related issues.

From 2019 through 2023, Water Alliance members tackled invasive species by purchasing CD3 equipment to remove invasive species from boats, planted more than forty Healthy Lakes buffer strips and rain gardens around the lake, and provided funds to farmers for cover crops in the watershed. It also provided funding to test more than ten of the Lake's tributaries that were suspected of bringing pollutants into the lake.

In 2022, the Water Alliance through the GLC received a WDNR grant to help fund an update to the Geneva Lake Management Plan to provide a comprehensive plan for the lake to guide all stakeholders and organizations. The GLC and Water Alliance supported additional data collection efforts needed to inform this planning effort and raised the remaining funds needed to complete the plan. Water Alliance members also hosted meetings to inform their constituents and the public on issues described in the plan, the plan development progress, and share means to provide comments on the plan. The Water Alliance intends to meet to discuss and coordinate the responsibilities described in this plan to help protect the Lake.

[1] https://wisconsinlandwater.org/success-stories/keeping-geneva-lake-blue

Current Lake Management Roles

Although there are multiple stakeholder organizations invested in the health of Geneva Lake (see "Lake Stakeholder Organizations" in Section 2.3), this list of organizations does not include a lake district. A lake district is a special purpose unit of government that is formed with the intent of protecting and improving the quality of a lake for the good of the district members and the environment. Many large lakes in southeastern Wisconsin have a lake district, although several do not and still maintain robust lake monitoring and management programs. In many of these instances, including Geneva Lake, one or more municipalities exercise the authorities and powers that could be granted to a lake district. Notable examples of these lakes include Delavan Lake in Walworth County with lake management by the Town of Delavan, the Delavan Lake Sanitary District, and the Delavan Lake Improvement Association; Pewaukee Lake in Waukesha County with management by the Lake Pewaukee Sanitary District, City of Pewaukee, the Village of Pewaukee, and the Town of Delafield; and Nagawicka Lake in Waukesha County with management by the City of Delafield.

As in the examples listed above, multiple stakeholder organizations on Geneva Lake have assumed roles over aspects of lake management that a lake district may typically oversee. For example, lake districts may:

- Collect data and/or fund studies of the lake and its watershed
    - Role currently primarily held by GLEA with support from GLC, GLA, and other organizations
- Establish boating ordinances with authority granted by municipalities
    - Role currently held by municipalities through the joint uniform lake law ordinance[69]
- Operate water patrols to enforce boating ordinances
    - Role currently held by the Geneva Lake Law Enforcement Agency, an inter-municipal organization, with funding support and regulation from WDNR
- Own and manage public boat launches
    - Role currently held by municipalities with regulation by WDNR
- Owning and operating a dam affecting lake water levels
    - Role currently held by the Geneva Lake Level Corporation with regulation by WDNR
- Participate in aquatic plant and aquatic invasive species monitoring and management
    - Role currently held by GLEA and municipalities with support from other organizations
- Provide educational materials on lake ecology and how to protect lake health

[69] *For a summary of the joint uniform lake law ordinances established by the municipalities for Geneva Lake, see the following link: https://genevalakepolice.com/resource-doc/LAKE%20ORD%20Flyer.pdf.*

    - Role currently held by GLEA, GLC, GLA, and other organizations
- Enhance boater safety through educational materials and outreach events
    - Role currently held by Geneva Lake Water Safety Patrol
- Improving lake health by implementing shoreline habitat projects and protecting sensitive lands near lake from development
    - Role currently primarily held by GLEA and GLC with support from multiple organizations

It is worth noting that the Geneva Lake community currently supports more lake management activities than most other lake communities, even those with lake districts, in southeastern Wisconsin. Few other lakes in southeastern Wisconsin have the robust, long-term water quality data collection efforts; financially supported water patrols; or the numerous habitat improvement efforts and programs that Geneva Lake benefits from.

There are multiple other aspects of lake and watershed management where the authority does not reside with a lake district but is granted to other entities (see Table 3.4). For example, a lake district or another organization need to apply for permits from the WDNR for many in-lake management activities, such as aquatic plant management, placing buoys, or dredging. Similarly, although erosion control, stormwater management, and land use zoning (including shoreland zoning) can affect lake health, regulation of these issues are not within the powers granted to a lake district but remain with the municipalities and the Counties. Consequently, effective lake management requires cooperation from multiple entities, including lake organizations, municipalities, Counties, and state agencies.

Lake Management Alternatives

It is the understanding of Commission staff that the current division of lake management activities and roles are not intended to be a long-term lake management structure. Some stakeholders would like to rescind their current management roles that were temporarily adopted in the absence of an alternative to focus on the main goals of their organizations. Several stakeholders have expressed an interest in greater fundraising capacity for lake management and would like to explore alternatives that can provide a more long-term fundraising base. Additionally, there are concerns that some non-resident property owners, not being primary residents of the surrounding municipalities, are not well-represented by the current municipal governance as these owners lack representation regarding lake management. There has been an expressed desire to house more lake management roles and responsibilities under a single entity, such as a lake district, instead of the web of partnerships that currently exists. The following subsection will present alternatives to the current lake management structure that may help address these concerns and develop a better funded and more cohesive management organization.

Institutionalize Current Roles

As described above, the multiple organizations involved in lake management activities on Geneva Lake are fulfilling many of the lake management roles undertaken by most lake districts throughout southeastern Wisconsin. Except for large-scale aquatic plant management, which is not currently recommended for Geneva Lake, this coalition of organizations is accomplishing more than most lake districts do for their lakes. Consequently, one option for future lake management is to institutionalize the current roles and collaborate more closely to achieve larger goals than any one organization could accomplish. This management option would require commitments from each organization to perpetually fund, maintain, and potentially expand their current lake protection programs. Maintaining a strong partnership comprised of a diverse group of stakeholder organizations enables greater outreach to Lake users and potential donors by speaking to a wide range of interests for protecting lake health. However, the Commission understands that some organizations would prefer to delegate their activities to another entity, which may make this option unacceptable. Regardless of whether the current management roles are maintained, or a new management structure materializes, it is recommended that the current partnership should continue to promote and support programs and practices that protect lake and watershed health.

Reinforce the GLEA

The GLEA was established in 1971, three years prior to the formation of lake districts under Chapter 33 of the *Wisconsin State Statutes*. As an intermunicipal agency, the GLEA is funded by four of the five municipalities on the lake, the Town of Walworth being the exception, with the purpose of studying and managing the lake. Representing shared municipal interests in managing the Lake, the GLEA board is comprised of ten members with two members from each of the five municipalities.[70] One member is appointed by each City Mayor, Village President, and Town Chair while the other member is designated by the governing body of each municipality. The GLEA Chair can form a Public Advisory Group to solicit public feedback on the GLEA and its activities. At the GLEA board meetings, each municipality and other lake

[70] *Geneva Lake Environmental Agency Uniform Resolution, Creating a Lake Management Agency Under and Pursuant to Section 66.0301* Wis. Stats., *ttps://www.gleawi.org/_files/ugd/456c61_ff59c9f31a344eb3a42530e5707a8e9f.pdf*

stakeholders are invited to present updates on lake management issues, such as progress regarding boat launch repairs and lagoon dredging, erosion control projects, and development within their respective jurisdictions. The GLEA director also presents to the GLEA board and the attending public on ongoing lake studies, grants, staffing, and projects. This organization structure and focus is somewhat similar to a lake district but differs primarily in that the GLEA cannot levy a tax to fund lake management, the GLEA board and annual budget are not voted upon by residents, and the GLEA does not have the authority to establish and enforce boating ordinances or exercise the powers of a sanitary district (see Table 3.5).[71][72] These authorities reside with the municipalities that have agreed to form the GLEA as an inter-municipal agency.

The primary concerns regarding the GLEA as the premier lake management agency include its limited capacity to fund lake management projects, low staff capacity to support lake improvement programs, and its lack of authority to enforce ordinances on the lake and at public launches. As per the 2023 budget, the GLEA revenues were $140,000 in municipal contributions, $41,612 in grants, $269 in interest income, and $50,235 in donations and fundraisers while major expenses were staff payroll and benefits, water quality monitoring, and supporting Clean Boats, Clean Waters and education programs.[73] With this budget, the GLEA has limited remaining funding for either hiring additional staff to expand lake management programs or to pay the large expenses that lake management projects can incur. These concerns regarding the GLEA staffing and funding were raised by the GLEA Director in the April 2023 GLEA meeting minutes.[74]

Significantly increasing revenues for the GLEA would enable the organization to increase staffing capacity and absorb some of the programs currently operated by other lake stakeholders (e.g., the GLC currently helps to administer WDNR Healthy Lakes & Rivers grants to install best management practices on lakeshore properties). The GLEA is currently expected to raise half of its revenues from donations, grants, and fundraising, but in the 2023 budget these contributions only constituted 39.5 percent of its revenues.[75] Grants and donation amounts can fluctuate significantly year-to-year and do not provide a consistent stream of revenue upon which additional staff or programs could be added to the GLEA. Consequently,

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[71] *The 2008 Geneva Lake management plan states that the community at that time felt that the GLEA was "an effective means of addressing lake management concerns." See SEWRPC CAPR 60 (2nd Edition),* A Lake Management Plan for Geneva Lake, *May 2008 for more information. https://www.sewrpc.org/SEWRPCFiles/Publications/CAPR/capr-060_2nd_ed_lake_management_plan_for_geneva_lake.pdf*

[72] *Lake districts must be delegated the powers to establish and enforce boating ordinances as well as operate a sanitary district by the municipalities.*

[73] *https://www.gleawi.org/_files/ugd/456c61_92195376bb7542988e631a87b60bde79.pdf*

[74] *https://www.gleawi.org/_files/ugd/456c61_3d75e6a6f4a14734883ffee5135e3c7b.pdf*

[75] *Several of these grants were for specific projects and thus could not be used for general staffing needs.*

municipal contributions to the GLEA would need to increase to provide that consistent revenue stream upon which the GLEA could afford the staff necessary to absorb lake management programs, such as sponsoring WDNR Healthy Lakes & Rivers grants, cost-sharing best management practices, and helping to fund in-lake management projects. These increases could potentially come by establishing special assessments or special assessment districts to riparian properties in the City of Lake Geneva, Villages of Fontana and Williams Bay, and the Towns of Linn; these districts could levy a tax from these riparian properties to help fund general GLEA staffing and operations. This tax revenue could partially replace or further extend the current municipal contributions to the GLEA. The municipalities could also consider modifying the GLEA bylaws to allow for the citizen representatives on the GLEA board to be elected by those property owners to which the special assessments are applied; this modification would allow those property owners (including non-resident owners) with a greater investment in the Lake to be more represented in decisions affecting the Lake.[76]

Regarding enforcement, the organizations with the authority to establish and enforce ordinances on the lake are the GLLEA, with authority granted by the municipalities through the joint uniform lake law ordinance, and WDNR wardens. The municipalities also own the public launches across the lake and thus have the authority to fine watercraft for violating *Wisconsin State Statutes* Chapter 30 aquatic invasive species ordinances. The GLEA bylaws, as currently written, do not provide the authority to establish or enforce ordinances on Geneva Lake. The authority to establish and enforce these ordinances would remain with the municipalities barring a rewriting of the GLEA bylaws that would enable them to adopt this authority. However, enabling this authority would also require significant increases in GLEA funding to properly support such a change.

Create a Lake District

As a unit of government with authority granted through *Wisconsin State Statutes* Chapter 33, lake districts can raise funds through taxation of district members, hold e lections for district leadership, and have legal requirements like open meetings and public records.[77, 78] As defined in Chapter 33, additional powers of

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[76] *In this scenario, the Town of Walworth citizen representative on the GLEA board would still be appointed by the Town governing body as the Town does not contribute financially toward the GLEA.*

[77] Wisconsin State Statutes *Chapter 33 Subchapter IV, Public Inland Lake Protection and Rehabilitation Districts. https://docs.legis.wisconsin.gov/statutes/statutes/33/iv/21*

[78] *For more information on lake district operation and formation, see* People of the Lakes: A Guide for Wisconsin Lake Organizations*, 12th Edition, University of Wisconsin-Extension Lakes Program, 2018. https://www3.uwsp.edu/cnr-ap/UWEXLakes/Documents/organizations/Lake%20Districts/Lake_Org_Guide2018.pdf*

lake districts include the capacity to sue and be sued; make contracts; accept gifts; purchase, lease, devise, acquire, hold, and maintain property; disburse funds; contract debt and do other acts as necessary to carry out a program of lake protection. District boundaries are typically comprised of riparian property owners but may include other properties near the lake or within its watershed. To form a lake district, the following steps must be taken:

- Receive approval from all city councils and village boards with lands within proposed district boundaries
- Develop a petition to the County Board of Supervisors to form a lake district and have the petition signed by 51 percent of landowners within the district or owners of 51 percent of the land area in the district
    - Alternatively, city councils, village boards, and town boards can represent all persons owning lands within their jurisdictions and sign on behalf of qualified landowners
- File the petition with the County Clerk, which prompts a public hearing on the formation of the lake district by a committee formed by the County Board
- The appointed committee will report its findings to the County Board within three months of the public hearing
- The County Board will issue an order granting or denying the petition to form a lake district

The County Board appoints four of the five initial lake district board members. The initial board must consist of three landowners within the district and a member of the County land conservation committee, all appointed by the County Board, as well as a member appointed by the governing body of the municipality with the largest assessed value of property in the district.[79]

A lake district could be created for Geneva Lake as outlined in the district formation process described above or by converting the Linn Sanitary District into a lake district. Compared to the current structure of lake management organizations, here are the changes that could occur with formation of a lake district:

- Taxing authority on properties within the district could significantly increase funding for lake monitoring and management
    - General property taxes are capped at $2.50 per $1,000 of equalized valuation and can be used for operational expenses such as monitoring and lake studies

[79] *If the proposed district boundaries included just riparian properties, the board member would likely be appointed by the Town of Linn as it has the largest total assessed property value of any municipality.*

        - District tax levies are approved by the district annual meeting. The total assessed value of properties within the district are equalized among the municipalities in the district by the Wisconsin of Revenue. The taxes are collected by municipal treasurers accordingly and distributed to the district.
    - Special charges, not to exceed $2.50 per $1,000 of assessed valuation (value assigned to total taxable property by municipal assessor), can be applied for services identified in the annual budget
    - Special assessments can be levied against benefited property for capital projects
- District property owners, including non-residents, could directly elect the officials involved in lake management decisions as well as funding appropriations for lake management
    - At the annual meeting, the district property owners present at the meeting would approve the annual budget, vote on taxes, approve borrowing of funds, appropriate money for the conservation of natural resources, create funds to finance capital costs and maintain equipment, and/or dissolve the district
- If delegated by the municipalities, the lake district could assume the authority over boating regulations and ordinances on Geneva Lake
    - Ordinances enacted by the lake district would still need to be authorized by resolutions adopted by at least one half of the municipalities on the lake and these municipalities would need to contain at least 60 percent of the lake frontage
- If granted by the municipalities, the lake district could take on ownership of the municipal launches on the lake
- The lake district could operate a lake patrol staffed by law enforcement officers to enforce state and local boating ordinances
    - If the district obtains ownership over a boat launch, the lake patrol could enforce state and local ordinances at the launch

Defining the lake district boundaries is important for determining how much revenue a district could generate as well as influencing how a district is likely to operate. As noted above, a lake district could significantly increase the revenue directed toward lake management on Geneva Lake. If a lake district was formed with boundaries that only included riparian properties, the estimated district revenue could be up to $6 million based on the 2024 total assessed property valuations and a mill rate of 2.5.[80] Using a mill rate of 0.6, which is more consistent with other lake districts in southeastern Wisconsin, the estimated district revenue could be up to $1.5 million. Instead of using a mill rate, some lake districts apply flat fees that range from $50 to $500 per property. Using similar fees would result in revenues between $60,000 and $600,000 if the district boundaries included the riparian properties.

These estimated revenues could be expanded if the district boundary included a larger area, such as the entire Geneva Lake watershed, but this would require that a majority these property owners are interested in joining the lake district. Such an extensive district would also grant many more votes on the district board and annual budget to the watershed residents compared to the riparian owners, who may be less interested in funding lake management efforts than the riparian owners. Given that the total assessed property values decline significantly for properties in the watershed without lake access, there is little benefit from a revenue generation standpoint to including many properties without lake access in the district. The creation of an overly large district may render it ineffectual without the ability to pass an annual budget or raise any revenue at all if the district members are not interested in lake management.

The district boundaries also have important consequences for the district board. As mentioned above, the district board must contain one member appointed by the municipality with the largest total assessed property value. This requirement may prove a challenge for district formation given that there are five municipalities with riparian properties and each municipality may want representation on the board. A district boundary could potentially be drawn to ensure representation in this municipal position from any single municipality apart from the Town of Walworth. To avoid conflicts with the excluded municipalities, the district could be established with a seven-member board where the five non-municipal and non-County board positions are represented with one member from each of the five municipalities. In this respect, the district board composition would be much like the current GLEA board.

A lake district could assume authority to establish and enforce boating ordinances only if this authority is delegated to the district by the municipalities. Discussions regarding the delegation of this authority, the ability for the municipalities to recommend changes to the boating ordinances, and the governance and

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[80] Commission staff estimated the potential district revenue from 1,322 parcels within 50 feet of Geneva Lake. The combined 2024 total assessed value of these parcels was just over $2.4 billion. Many additional properties have access to Geneva Lake and may also be considered for inclusion in the lake district boundaries, such as the Abbey Marina as well as properties in homeowners associations that have a shared lake access.

funding of the Geneva Lake Law Enforcement Agency (GLLEA) should occur in the preliminary stages of forming the district. A lake district could still be created even if the authority to establish and enforce boating ordinances remains with the municipalities and the GLLEA.

Additionally, the lake district could operate and enforce ordinances at public boat launches but only if these launches were acquired by the municipalities that currently own and operate them. As with the boating ordinances, discussions regarding the acquisition of these launches, funding their operations and staffing, and the delegating the authority to enforce local ordinances affecting the boat launch should occur in the preliminary stages of forming the district.

There are several other lake management activities and jurisdictions whose authority could not be delegated to a lake district. These include land use and zoning (including shoreland zoning), erosion control and stormwater management permitting, and pier and waterway marker permitting. Lake districts are not granted these powers as described in Chapter 33 of the *Wisconsin State Statute*. Like the GLEA or a non-profit organization, the district could act as an advocate for changes to the laws and ordinances that regulate these activities, apply for permits to implement in-lake management practices, or help fund best management practices in the watershed.

Expanding or Converting the Linn Sanitary District

Like lake districts, sanitary districts are also special purpose units of government that can be granted the powers to undertake lake management activities. These powers may include the operation of a water safety patrol, aquatic plant management operations, undertaking projects that enhance recreation on public lands including boating facilities, leasing or acquiring properties, and appropriating funds for the conservation of natural resources. Unlike lake districts, the annual budget for the sanitary district is voted on by the sanitary district commissioners rather than by the members of the district. Local examples of sanitary districts that are involved in lake management activities include the Browns Lake Sanitary District on Browns Lake in Racine County, the Delavan Lake Sanitary District on Delavan Lake in Walworth County, and the Lake Pewaukee Sanitary District on Pewaukee Lake in Waukesha County.[81,82,83]

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[81] *https://www.brownslakesanitarydistrict.com/*
[82] *https://dlsd.org/*
[83] *https://lakepewaukee.org/*

If the sanitary district includes the entire lake shoreline, then the municipal board may convert the sanitary district into a lake district by resolution. In the case of Geneva Lake, the Linn Sanitary District only encompasses 50.1 percent of the Lake shoreline and thus the Sanitary District must receive approval from the Town of Linn board to petition the Walworth County board for conversion into a lake district. As part of this conversion, the Sanitary District could be expanded to include more lake frontage. Any additions beyond the current extent of the sanitary district would require landowners in this expansion to sign a petition signifying their willingness to join the lake district. However, a lake district could also be formed alongside the Linn Sanitary District with the lake district assuming responsibility over lake management and the Linn Sanitary District retaining their current responsibilities. Silver Lake in Washington County is one example of a lake with a lake management district, a sanitary district, and a lake association.

Form a Water Commission

Another alternative lake management structure is the formation of a commission as detailed in *Wisconsin State Statute* Chapter 33. Unlike lake management districts, which have preset and defined rules regarding their formation, structure and operation as described earlier in this chapter, commissions do not have such preset rules and are individually created in the State legislature. Only two commissions addressing public inland waters have been created in Wisconsin to date: the Dane County Lakes and Watershed Commission and the Southeast Fox River Commission.[84,85,86] Although each commission was created independently, they do share some similarities in having a board of commissioners comprised of the municipalities within their jurisdiction, implementing projects that will enhance the water quality of the public waters within their jurisdiction, and that they work with their respective regional planning commissions to develop an implementation plan. Neither commission has the authority to directly tax the properties within their jurisdictions; the Dane County Lakes and Watershed Commission may petition the Dane County board to levy a tax to fund the commission while the Southeast Fox River Commission receives earmarked funds from the state legislature and does not have taxing authority. Additionally, neither commission has the authority to establish regulations regarding the waterbodies within their jurisdiction but may propose ordinances and regulations that could be adopted by the municipal or County governing bodies.

[84] Wisconsin State Statutes *Chapter 33 Subchapter V, Dane County Lakes and Watershed Commission. https://docs.legis.wisconsin.gov/statutes/statutes/33/v/*

[85] Wisconsin State Statutes *Chapter 33 Subchapter VI, Southeastern Wisconsin Fox River Commission. https://docs.legis.wisconsin.gov/statutes/statutes/33/vi/*

[86] *For more information on the Southeastern Wisconsin Fox River Commission, see http://www.sewfrc.org/.*

The benefits to forming a Geneva Lake commission would be the flexibility in designing an organization that best meets the unique needs of Geneva Lake as one of the State's largest and most visited lakes. This commission could be created with a board that includes representation from each of the municipalities on the Lake as well as elected representatives from lake property owners within an established jurisdiction. Additionally, this commission could be granted the authority to levy taxes and/or receive municipal contributions. However, this flexibility also provides a challenge as the organization structure, funding, and responsibilities would need to be approved by the State legislature and signed into law as a subchapter of Chapter 33 of the *Wisconsin State Statutes*. The commissions that have been authorized by the State legislature function much like the GLEA already does for Geneva Lake, with broad municipal representation but lacking taxing or regulatory authority. As the current commissions authorized by the State legislature have less regulatory and taxing authority over the waters in their jurisdiction than a lake district, it is unclear whether the legislature would approve of a commission with these powers, particularly when the option to form a lake district already exists. However, forming a commission with the primary benefit of increased potential funding is a viable consideration for a lake as large and significant as Geneva Lake.

3.11 CLIMATE CHANGE

Climate change is a current and future threat to Wisconsin lakes. Climate change is expected to bring a myriad of impacts, many of which are already being seen. Warming air temperatures of 3-9 degrees Fahrenheit by 2050 will contribute to increasing water temperatures leading to a decline in habitat and spawning success for cool and cold-water fishes. Warming temperatures will also lead to a decrease in ice duration and thickness on lakes, particularly larger lakes with a higher heat budget. Wisconsin can expect to continue to see increased frequency, duration and intensity of precipitation events with the annual average precipitation expected to increase by 2 inches per year. This can cause increased erosion of stream channels that result in deep gullies that intensify stream flow, which some tributaries of Geneva Lake are already experiencing. While Geneva Lake has already begun to see some changes due to climate change, its volume and abundant groundwater will help serve as a buffer against rising air temperatures compared to other southern Wisconsin lakes.

All recommendations provided in Chapter 3 have been made with climate change impacts in mind. The recommendations made will not necessarily stop climate change, they will help Geneva Lake be buffered against the impacts of climate change. Many of the recommendations provided are those encouraged by the Wisconsin Initiative on Climate Change Impacts ("WICCI").[87]

3.12 PLAN IMPLEMENTATION

The methods to implement this plan vary with recommendation type, with efforts required, and can be achieved by education and outreach, ordinances and regulations, as well as partnership and collaboration. To help implement plan recommendations, Table 3.1 summarizes all recommendations and their priority level while Figures 3.1, 3.2, and 3.3 provide a visual overview of where to target management efforts. Table 3.2 provides a table of select management recommendations with estimated costs, phosphorus reduction amounts (as relevant), potential funding programs, and suggested entities to implement the recommendations. Programs that may help fund recommended practices and programs are provided in Table 3.3. This section provides recommendations on how to successfully implement projects and recommendations provided in the management plan.

Awareness, Education, and Outreach

One of the most effective ways to promote plan implementation is educating lake residents, users, and governing bodies regarding the content of this plan. The following recommendations are intended to increase awareness of the management plan, engage interested parties, and encourage outreach that can lead to potential partnerships and collaboration.

- **Recommendation 7.1: Integrate lake users and residents into management efforts**

  This is recommended as a high priority. The aim of this effort is to add to the donor and volunteer base working toward improving the Lake, improving community buy-in, and receiving greater community input on lake planning and management decisions. Private donations and volunteer time can be used as cost match for some grants.

- **Recommendation 7.2: Encourage key players to attend meetings, conferences, and/or training programs to build their lake management knowledge**

  These actions as recommended as a medium priority as they will enhance institutional capacity. Some examples of capacity-building events are Wisconsin Water Week (which targets local lake managers) and the "Lake Leaders" training program (which teaches the basics of lake management and provides

[87] *https://wicci.wisc.edu/wp-content/uploads/2019/12/climate-wisconsin-2050-lakes.pdf*

ongoing resources to lake managers). Both are hosted by University of Wisconsin Stevens Point Extension Lakes.[88] Additionally, courses, workshops, on-line training, regional summits, and general meetings can also be used for this purpose. Another excellent local source of good information for pursuing soil health initiatives includes attending free meetings and field demonstrations sponsored by producer-led groups.[89] Attendance at these events should include follow-up documents and meetings so that the lessons learned by the attendee can be shared with the larger lake group.

- **Recommendation 7.3: Continue to ensure inclusivity and transparency with respect to all Lake management activities**

  If stakeholders do not fully understand the aims and goals of a project, or if they do not trust the process, excess energy can be devoted to conflict, a result that benefits no one. For this reason, this element is assigned high priority. These efforts should be implemented through public meetings and consensus building so that conflicts can be discussed, addressed, and mitigated before implementing projects.

- **Recommendation 7.4: Foster and monitor management efforts to communicate actions and achievements to future lake managers**

  Institutional knowledge is a powerful tool that should be preserved whenever possible. Actions associated with this are sometimes embedded in organization bylaws (e.g., minutes) and are therefore assigned medium priority. Open communication helps increase the capacity of lake management entities. This may take the form of annual meetings, websites, newsletters, emails, reports, and any number of other means that help compile and report action, plans, successes, and lessons learned. Several lake stakeholder organizations, including the GLEA and GLA, provide newsletters to update homeowners about lake issues.[90,91] These records should be kept for future generations and made publicly accessible.

Ordinances and Regulations

Several important recommendations relate to enforcing current ordinances (e.g., shoreline setbacks, zoning, construction site erosion control, and boating). Public agencies often have limited resources available to

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[88] *www.uwsp.edu/cnr-ap/UWEXLakes/Pages/default.aspx*

[89] *The closest producer-led group meetings are held by the Walworth Alliance Teaching Environmental Regenerative Systems. For more information on this and other producer-led groups, see the following webpage: https://datcp.wi.gov/Pages/Programs_Services/ProducerLedProjectSummaries.aspx#walworth.*

[90] *https://www.gleawi.org/geneva-waters-newsletter*

[91] *https://genevalakeassoc.org/newsletter-archives*

monitor compliance and affect enforcement. Consequently, the following recommendations are aimed at local citizens and management groups and are made to enhance the ability of responsible entities to monitor compliance and enforce regulations.

- **Recommendation 7.5: Actively share this plan and work with municipalities to adopt it**

  Facilitating plan adoption can occur by maintaining and enhancing relationships with County, municipal zoning administrators, directors of public works/municipal engineers, and law enforcement officers. This helps build open relationships with responsible entities and facilitates efficient communication and collaboration whenever needed. This should be assigned a high priority.

- **Recommendation 7.6: Continue to advocate for responsible development in the watershed and protection environmental corridors, high priority groundwater recharge areas, and other open lands critical to lake health**

  Certain activities (e.g., construction, filling, excessive erosion) could potentially affect the Lake. This initiative includes maintaining good records (e.g., notes, photographs) and judiciously notifying relevant regulatory entities of problems when deemed appropriate. This recommendation should be assigned a high priority.

- **Recommendation 7.7: Educate all watershed residents and landowners about relevant water and land use ordinances and enforce ordinances. Update ordinances to protect environmental corridors and high priority groundwater recharge areas and ensure that proposed development is designed to prevent harm to the Lake and its tributaries.**

  This helps ensure that residents know why rules are important, that permits are required for almost all significant grading or construction, and that such permits offer opportunity to regulate activities that could harm the Lake. This should be considered a medium priority.

Partnership and Collaboration

Numerous opportunities exist for partnership and collaboration to improve water quality within the watershed. The following recommendations provide ideas and collaboration opportunities intended to inspire further action.

- **Recommendation 7.8: Foster open relationships with potential project partners**

Continue to partner with and maintain good relations with volunteer groups, municipalities, and governing bodies, which promotes effective solutions to issues shared. This is recommended as a high priority.

- **Recommendation 7.9: Apply for available grants to support implementing programs recommended as part of this plan**

The GLC, GLEA, municipalities, Walworth County, and/or other local units of government may apply for grants from WDNR to control non-point source pollution and meet the TMDL load allocation as well as for other surface water related projects. The WDNR, DATPC, and the Federal government support nonpoint source pollution abatement by administering and providing cost-sharing grants to fund BMPs through various grant programs. Sponsoring and applying for such grants is potentially the most important avenue for the lake stakeholders to implement recommended BMPs within the Lake watershed. Having multiple collaborators providing external funding support, including equipment, volunteer hours, and cash, enhances the odds of a successful WDNR grant application. This is recommended as a high priority.

Funding Sources

The following subsection briefly describes potential State and Federal funding sources available to help fund BMPs and other plan recommendations in the watershed. This is not an exhaustive list. However, the list but does include some of the more common funding sources. Additional funding information is provided in Table 3.3.

State

- **Surface Water Grant Program (SWG)** – A WDNR program that offers competitive grants for local governments, counties, lake districts, and other eligible organizations to address a range of surface-water issues.[92] Several subprograms could be useful for implementing plan recommendations and that the GLC, GLEA, municipalities, and Walworth County could sponsor. These subprograms include:
  - **Surface Water Restoration** – Provides funds to implement shoreline, in-water, and wetland restoration projects that follow appropriate NRCS guidelines as well as funding to develop ordinances that protect surface water resources. Cost-share is up to 75 percent of eligible costs for up to $75,000 for lakes and $50,000 for rivers.

[92] For more information on the WDNR Surface Water Grant program, see www.dnr.wisconsin.gov/aid/SurfaceWater.html and Wisconsin Department of Natural Resources, 2021 DNR Surface Water Grant Application Guide, July 2021: www.dnr.wi.gov/files/pdf/pubs/cf/CF0002.pdf.

- **Management Plan Implementation** – Provides funds to implement recommendations in a WDNR-approved surface water management plan. Eligible projects include nonpoint source pollution control, habitat restoration, water quality improvements, landowner incentives, and management staffing. Cost-share is up to 75 percent of eligible costs for up to $200,000 for lakes and $50,000 for rivers.
- **Healthy Lakes and Rivers** – Provides funding to implement approved best practices for shoreland landowners following technical guidance. Practices include fish sticks, native plantings, water diversions, rain gardens, and rock infiltration. Cost-share is up to 75 percent of eligible costs for up to $25,000.
- **Clean Boats, Clean Waters** – Provides funding to help prevent spread of aquatic invasive species through education and monitoring at boat launches. Eligible costs include supplies, training, and payment to any paid staff or in-kind donations from volunteers. Cost-share is up to 75 percent of eligible costs for up to $4,000 per boat launch.
- **Land Acquisition** – Provides funding to permanently acquire land to protect surface waters. Eligible costs include costs associated with appraisal, land survey fees, title costs, and any historical, cultural, or environmental assessments. Cost-share is up to 75 percent of eligible costs for up to $200,000 for lakes and $50,000 for rivers.

- **Targeted Runoff Management (TRM) Grant Program** – WDNR program that offers competitive grants for local governments for controlling nonpoint source pollution. Grants reimburse costs for agricultural or urban runoff management practices in critical areas with surface water or groundwater quality concerns. The cost-share rate for TRM projects is up to 70 percent of eligible costs.[93]

- **Soil and Water Resources Management Grant Program** - DATCP program that provides funds to Counties allowing them to enter cost-share contracts with landowners implementing eligible conservation practices. The cost-share rate depends on the conservation practice being implemented but can be up to 70 percent for practices associated with NR 151 performance standards and up to 90 percent if the landowner qualifies for economic hardship. Practices required as part of a CAFO or other WPDES permit are ineligible for cost-sharing.[94]

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[93] For more information on TRM, see www.dnr.wisconsin.gov/aid/TargetedRunoff.html.

[94] *For more information, see www.datcp.wi.gov/Pages/Programs_Services/SWRMGrantResources.aspx.*

- **Farmland Preservation Program** – DATCP program that provides a tax credit per acre to eligible farmlands complying with NR 151 agricultural performance standards. Tax credits can vary from $5.00 to $10.00 per acre, depending on the zoning status of the farmland.[95]

- **Notice of Intent/Discharge Grant Program** – Joint WDNR and DATCP program that provides funds to local governmental units working with livestock operation owners and/or operators that have received a Notice of Discharge or Notice of Intent to Issue a Notice of Discharge from WDNR. Eligible BMPs include those designed to improve water quality affected by livestock pollutant discharge. The cost-share rate for these projects is up to 70 percent of eligible costs.[96]

Federal

- **Conservation Reserve Program (CRP)** – A land conservation program administered by the USDA Farm Service Agency. Farmers enrolled in the program receive a yearly rental payment for environmentally sensitive land that they agree to remove from production. Contracts are 10 to 15 years in length. Eligible practices include buffers for wildlife habitat, wetland buffers, riparian buffers, wetland restoration, filter strips, grass waterways, shelter belts, living snow fences, contour grass strips, woodland establishment, and shallow water areas for wildlife.[97]

- **Conservation Reserve Enhancement Program (CREP)** – Joint effort between County, State, and the Federal government providing funds for practice installation, rental payments, and an installation incentive. Administered by the Farm Service Agency. Interested parties can enter a 15-year contract or perpetual contract conservation easement. Eligible practices include filter strips, buffer strips, wetland restoration, tall grass prairie and oak savanna restoration, grassed waterway, and permanent native grasses.[98]

- **Agricultural Conservation Easement Program (ACEP)** – USDA NRCS program that consolidates three former programs (Wetlands Reserve Program, Grassland Reserve Program, and Farm and

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[95] *For more information, see www.datcp.wi.gov/Pages/Programs_Services/FarmlandPreservation.aspx.*
[96] *For more information, see www.dnr.wisconsin.gov/aid/NOD.html.*
[97] For more information on CRP, see www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program.
[98] For more information on CREP, see www.datcp.wi.gov/Pages/Programs_Services/CREPLandowners.aspx.

Ranchlands Protection Program). Under this program, NRCS provides financial assistance to eligible partners for purchasing Agricultural Land Easements that protect the agricultural use and conservation values of eligible land.[99]

- **Conservation Stewardship Program (CSP)** – USDA NRCS program that offers funding for participants that take additional steps to improve resource condition. Program provides two types of funding through five-year contracts: 1) annual payments for installing new practices and maintaining existing practices and 2) supplemental payments for adopting a resource-conserving crop rotation.[100]

- **Farmable Wetlands Program (FWP)** – USDA Farm Service Agency program designed to restore previously farmed wetlands and wetland buffer to improve both vegetation and water flow. The Farm Service Agency runs the program through the Conservation Reserve Program with assistance from other government agencies and local conservation groups.[101]

- **Aquatic Ecosystem Restoration Program (AERP)** – United States Army Corps of Engineers (USACE) program to plan, design, and implement aquatic ecosystem restoration projects located in the public interest and that have a non-federal public agency sponsor willing to maintain and rehabilitate the project site.[102]

- **Partners for Fish and Wildlife Program** – United Stated Fish & Wildlife Service program providing technical assistance and cost-share funding to incentivize fish and wildlife habitat restoration on privately owned lands.[103]

- **Environmental Quality Incentives Program (EQIP)** – USDA NRCS program that provides financial and technical assistance to implement conservation practices addressing natural resource

[99] For more information on ACEP, see www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep.
[100] For more information on CSP, see www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp.
[101] For more information on FWP, see www.fsa.usda.gov/programs-and-services/conservation-programs/farmable-wetlands/index.
[102] For more information on AERP, see www.sas.usace.army.mil/Missions/CAP/Section-206-Aquatic-Ecosystem-Restoration/.
[103] For more information on the Partners for Fish and Wildlife Program, see www.fws.gov/midwest/partners/getinvolved.html#a.

concerns.[104] Farmers receive flat rate payments for installing and implementing runoff management practices. Many agricultural practices are eligible for cost sharing.

3.13 SUMMARY

The future will bring change to Geneva Lake and its watershed. Projections suggest that some of the agricultural land use in the watershed of today will give way to urban residential land use. It is critical that proactive measures be pursued to lay the groundwork for effectively dealing with and benefiting from future change. Working relationships with appropriate local, County, and State entities need to be nurtured now and in the future. These relationships ultimately will help protect critical natural areas in the watershed during development, will help initiate actions (such as residential street leaf litter pickup and disposal), and will help instill attitudes among current and future residents that will foster cooperation and coordination of effort on many levels.

To help implement plan recommendations, Table 3.1 summarizes all recommendations and their priority level whiles Figures 3.1, 3.2, and 3.3 provide a visual overview of where to target management efforts.

As stated in the introduction, this chapter is intended to stimulate ideas and action. Therefore, these recommendations should provide a starting point for addressing the issues identified in Geneva Lake and its watershed. Successfully implementing this plan requires vigilance, cooperation, and enthusiasm, not only from local management groups, but also from State and regional agencies, Walworth County, municipalities, and Lake residents, Lake users, and the general public. Implementation of the recommended measures will provide the water quality and habitat protection necessary to maintain or establish conditions in the watershed that are suitable for maintaining and improving the natural beauty and ambience of Geneva Lake and its ecosystem. This, in turn, benefits the Region's human population today and in the future.

[104] *For more information on EQIP, see www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip.*

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A LAKE MANAGEMENT PLAN FOR GENEVA LAKE
WALWORTH COUNTY, WISCONSIN

Chapter 3 Tables

Table 3.1
Summary of Recommendations for Geneva Lake Grouped by Issues

Number	Recommendation	Priority	Primary Stakeholder(s)[b]
	HYDROLOGY/WATER QUANTITY		
	Surface Water Monitoring and Management		
1.1	Continue to monitor Geneva Lake's water surface elevation	High	GLLC
1.2	Continue to monitor and quantify the volume of water delivered to the Lake from the various (tributary) sub-basins	Medium	GLEA, WDNR
	Groundwater Monitoring and Protection		
1.3	Institute groundwater monitoring	Medium	USGS, GLEA
1.4	Curb growth of groundwater demand by carefully evaluating new developments that would impact groundwater supply to the Lake	Low-High[a]	GLEA, Munis.
1.5	Preserve or enhance groundwater water supplies by enhancing infiltration and limiting development on high groundwater recharge areas	Low-High[a]	All
	WATER QUALITY		
	Geneva Lake Monitoring		
2.1	Enhance ongoing monitoring efforts through USGS and beach testing	High	GLEA, USGS, Munis.
2.2	Continue water quality monitoring efforts in eastern basin of Lake	Medium	GLEA, USGS
2.3	Expand tributary water quality monitoring efforts	Medium	GLEA, WDNR
2.4	Continue collaboration with municipalities, health officials, and WDNR regarding E. coli and algae monitoring	High	GLEA, WDNR, Munis.
	Phosphorus Management		
2.5	Reduce nonpoint source phosphorus loads to the Lake	High	All
2.6	Manage factors that stimulate in-Lake phosphorus recycling	High	GLEA, WDNR
2.7	Support septic system inspection, pumping and maintenance efforts	Medium	Walworth County, Linn Sanitary District
	Chloride Management		
2.8	Municipalities and Walworth County should continue to reduce road salt applications using innovative practices	High	Munis., Walworth County
2.9	Reduce private and public salt applications by educating businesses and property owners about practicing smart salt management	High	GLC, GLEA, GLA
2.10	Optimize water softeners for water use and hardness levels and upgrade to high-efficiency softeners when practical	High	Munis.
	POLLUTANT AND SEDIMENT SOURCES AND LOADS		
	Forthcoming Fox River TMDL		
3.1	Permitted facilities should consider using an adaptive management approach to meet TMDL requirements	High	Munis.
	Agricultural Non-Point Source Loads		
3.2	Continue to assist landowners to prepare and implement conservation plans and conservation practices needed for compliance with NR 151	High	Walworth County, WDNR, DATCP
3.3	Incentivize use of no-till and conservation tillage practices and assist farmers and/or landowners in seeking funding for implementing such practices	Medium	Walworth County, WDNR, DATCP
3.4	Promote increased cover crop acreage and assist farmers and/or landowners in seeking funding for implementing such practices	Medium	Walworth County, WDNR, DATCP, GLC
3.5	Ensure all agricultural lands employ nutrient management plans and assist farmers in preparing and implementing these plans	High	Walworth County, WDNR, DATCP
3.6	Install additional grassed waterways, maintain existing waterways, and assist farmers and/or landowners seeking funding to implement such practices	Medium	Walworth County, WDNR, DATCP
3.7	Install additional water and sediment control basins, maintain existing basins, and assist farmers and/or landowners seeking funding to implement basins	High	Walworth County, WDNR, DATCP
3.8	Ensure that animal operation performance standards are met	High	Walworth County, WDNR, DATCP
	Urban Non-Point Source Loads		
3.9	Encourage urban pollution source reduction efforts through BMPs	High	GLC, GLEA, GLA
3.10	Inventory existing stormwater management practices and develop stormwater management plans	Medium	Munis.
3.11	Promote native plantings in and around existing and new stormwater detention basins	Medium	Munis.
3.12	Retrofit existing and enhance planned stormwater management infrastructure to benefit water quality	High	Munis.

Number	Recommendation	Priority	Primary Stakeholder(s)[b]
3.13	Combine riparian buffers with other structures and practices	Low	Munis.
3.14	Stringently enforce construction site erosion control and stormwater management ordinances and creatively employ these practices	Low	Munis.
3.15	Maintain stormwater detention basins	Low	Munis.
3.16	Collect leaves in urbanized areas on both private and public property	Low	Munis.
	Tributaries		
3.17	Control invasive buckthorn and honeysuckle along tributary corridors	High	GLA, GLC, GLEA
3.18	Reduce and slow stormwater contributions into tributaries	High	Walworth County, Munis.
3.19	Utilize regenerative stormwater conveyance practices	High	Munis., GLA
3.20	Repair, reduce, or retrofit drain tile systems	High	Walworth County
	Tributary-Specific		
3.21	Bigfoot Creek: Develop a wetland restoration plan for the Bigfoot Creek wetland	High	GLC
3.22	Abbey Springs Creek: Enhance buffer along stream in golf course	Medium	GLA, GLEA
3.23	Southwick Creek: conduct channel naturalization along the ditch parallelling STH 67	Medium	V. Williams Bay, GLC
3.24	Covenant Harbor Creek: Implement storm water improvements to the Wilkins Trust storm water retention basin on the Covenant Harbor property	Medium	C. Lake Geneva
3.25	Potawatomi and Van Slyke Creeks: Conduct storm water flood mitigation in STH 67 Pond	Low	V. Fontana
3.26	Potawatomi and Van Slyke Creeks: Restore Potawatomi Creek channel where it flows through Bigfoot Country Club	Low	V. Fontana
3.27	Potawatomi and Van Slyke Creeks: Restore floodplain connectivity in forested area of lower Van Slyke Creek	Low	V. Fontana
3.28	Potawatomi and Van Slyke Creeks: Restore wetland and conduct ravine stabilization on Potawatomi Creek channel near South Lakeshore Drive	Low	V. Fontana
3.29	Potawatomi and Van Slyke Creeks: Redirect stormwater flow away from directly inputting into a Potawatomi Creek tributary	Medium	V. Fontana
3.30	Potawatomi and Van Slyke Creeks: Remediate Main Street Ditch from Dewey to STH 67	Low	V. Fontana
3.31	Potawatomi and Van Slyke Creeks: Restore middle reach of Van Slyke Creek at location of historical millpond	Low	V. Fontana
3.32	Potawatomi and Van Slyke Creeks: Remediate Main Street ditch to allow for better flow and fish passage	Low	V. Fontana
3.33	Potawatomi and Van Slyke Creeks: Redirect stormwater flow to prevent runoff directly inputting into a Van slyke Creek Tributary near lower portion of the Stewart Property at the north side of Main Street	Medium	V. Fontana
3.34	Potawatomi and Van Slyke Creeks: Implement potential projects outlined in the 2009 Potawatomi/Van Slyke Report prepared for Fontana-on-Geneva-Lake	Low	V. Fontana
3.35	Gardens Creek: Consider saturated buffers in agricultural lands to encourage denitrification	Low	Walworth County
	Shoreline Maintenance		
3.36	Incorporate native vegetation into shoreline protection measures	High	GLC, GLEA, GLA
3.37	Support current programs, such as Conservation@Home, to promote native plantings and shoreline gardens	High	GLC, GLEA, GLA
3.38	Continue to sponsor WDNR Healthy Lakes & Rivers projects	High	GLC, GLEA, GLA
3.39	Collaborate with gardening groups to sponsor demonstration days and recognition for shoreline gardens, rain gardens, and other ecologically beneficial plantings	Medium	GLC, GLEA, GLA
3.40	Compile list of local contractors and landscape architects that support native plantings and shoreline practices	Medium	GLC, GLA
3.41	Reduce refracted wave energy	Low	GLA, GLEA, WDNR
	AQUATIC PLANTS		
	Aquatic Plant Management		
4.1	Conduct yearly surveys of starry stonewort populations to examine spread and population size	High	GLEA, WDNR
4.2	Conduct whole-lake aquatic plant point-intercept surveys once every 5-7 years	Medium	GLEA, WDNR
4.3	DASH could be employed by individuals to provide relief on nuisance native and nonnative plants around piers	Low	GLA, WDNR

Number	Recommendation	Priority	Primary Stakeholder(s)[b]
4.4	Monitor algal abundance and sample for algae toxins during suspected algal bloom conditions	High	GLEA
4.5	Warn residents not to enter the water in the event of an algal bloom	High	All
4.6	Encourage a healthy aquatic plant community to compete with algal growth	High	All
4.7	Consider acquiring small aquatic plant harvesters to address nuisance growth in highly trafficked areas	Medium	Munis.
	Invasive Species		
4.8	Continue participation in the Clean Boats, Clean Waters program	High	GLEA, Munis.
4.9	Fundraise and work with local municipalities to maintain AIS decontamination equipment at all public launches	Medium	GLEA, Munis.
4.10	Use mixture of whole-lake aquatic plant surveys and targeted surveys at launches to monitor AIS	High	GLEA, Munis.
4.11	Provide signage and education to properties with private boat launches and lake access to ensure the spread of invasive species is mitigated	High	GLEA, Munis.
4.12	Place advisory buoys surrounding the starry stonewort population to warn boaters of its presence and to limit activities in the colony areas that could increase its spread	Medium	GLEA
	FISH AND WILDLIFE		
5.1	Continue periodic monitoring of zooplankton, phytoplankton and rotifer populations in the Lake	Low	GLEA
5.2	Continue monitoring of nearshore fishery populations in the Lake	High	GLEA, WDNR
5.3	Collaborate with WDNR to survey and manage cisco population	Medium	GLEA, WDNR
5.4	Protect nearshore aquatic plant communities that provide habitat to the nearshore fishery	Medium	GLEA, WDNR
5.5	Introduce coarse and large woody habitat to areas to help restore nearshore fishery in the Lake	Medium	GLEA, WDNR
5.6	Identify and remove instream barriers to passage of fish and other aquatic organisms.	Low	WDNR
5.7	Current fishing practices and ordinances should continue to be enforced.	High	WDNR
	RECREATIONAL USE AND FACILITIES		
6.1	Collaborate with municipalities to develop, and post at launches, recreational use recommendations for the lake	High	GLLEA, WSP, Munis.
6.2	Encourage safe boating practices and boating pressure on the Lake	Medium	GLLEA, WSP, Munis.
6.3	Implement an education campaign with boat rental companies and marinas to educate visiting boaters on rules and recommendations	High	WSP, GLLEA
6.4	Consider conducting regular online surveys of recreational users to gather feedback about recreating on the Lake	Low	WSP, GLEA
6.5	Track and maintain shoreline and rock buoys stationed across the Lake	High	Munis, GLLEA, WDNR
6.6	Maintain and enhance fishing by protecting and improving aquatic habitat and ensuring the fish community remains viable	Medium	GLEA, Munis., GLA
6.7	Consider increasing launch fees during peak use periods	Medium	Munis.
6.8	Take action to reduce conditions leading to powerboat-induced shoreline erosion	Medium	WSP, GLLEA, GLEA, Munis.
	PLAN IMPLEMENTATION		
7.1	Integrate lake users and residents into management efforts	High	All
7.2	Encourage key players to attend meetings, conferences, and/or training programs to build their lake management knowledge	Medium	All
7.3	Continue to ensure inclusivity and transparency with respect to all Lake management activities	High	All
7.4	Foster and monitor management efforts to communicate actions and achievements to future lake managers	Medium	All
7.5	Actively share this plan and work with municipalities to adopt it	High	All
7.6	Continue to advocate for responsible development in the watershed and protect Environmental Corridors, high priority Groundwater Recharge Areas and other open land critical to lake health	Low	All
7.7	Educate all watershed residents and landowners about relevant water and land use ordinances and enforce ordinances. Update ordinances to protect Environmental Corridors and high priority Groundwater Recharge Areas and ensure that proposed development is designed to prevent harm to the lake and its tributaries	Medium	Munis., GLA, GLEA
7.8	Foster open relationships with potential project partners	High	All

Number	Recommendation	Priority	Primary Stakeholder(s)[b]
7.9	Apply for available grants to support implementing programs recommended as part of this plan	High	All

[a] *The priority is based on the sub recommendations.*

[b] *The following acronyms and abbreviations are used in this table: Geneva Lake Environmental Agency (GLEA), Geneva Lake Conservancy (GLC), Geneva Lake Association (GLA), multiple municipalities (Munis.), Geneva Lake Law Enforcement Agency (GLLEA), Water Safety Patrol (WSP), Wisconsin Department of Natural Resources (WDNR), the Department of Agriculture, Trade, and Consumer Protection (DATCP), and the United States Geological Survey (USGS).*

Source: SEWRPC

Table 3.2
Cost Estimates for Select Lake Management Recommendations

Recommendations	Practice/Indicator	Quantity	Estimated Cost ($)[a]	Phosphorus Reduction[b]	Funding Programs[c]	Implementation
Continue water quality monitoring program	Overall lake water quality monitoring and beach testing	Annually	$25,000 to $30,000	--	SWG	WDNR, USGS, Local Partners
Expand water quality monitoring to eastern basin	Conduct profiles and monitor trophic state	Annually	$10,000 to $15,000	--	SWG	WDNR, USGS, Local Partners
Continue participation in Clean Boats, Clean Waters program	Maintain staff and volunteers at each public launch	Annually	$10,000 to $15,000	--	SWG	WDNR, Local Partners
Monitor lake access points for invasive species	Meander surveys and/or sub-point-intercept surveys	Annually	$5,000	--	SWG	WDNR, Local Partners
Monitor health of aquatic plant community	Point-intercept survey of entire lake	At least once per five years	$10,000 to $15,000	--	SWG	WDNR, Local Partners
Enhance nearshore fishery habitat	Install fish stick projects along undeveloped shorelines	Up to 95 project sites	$95,000	--	SWG	WDNR, Local Partners
Reduce urban pollutant runoff	Enforce construction erosion site controls and stormwater management ordinances	Varies with land development	$450 to $900 per acre	Varies	UNPS&SW	Municipalities
Bigfoot Creek wetland restoration project[d]	Restore wetland functioning by managing invasive cattail and other measures	Up to 90 acres	$900,000 to $1,350,000	Varies	EQIP, TRM, SWG	NRCS, Walworth County, WDNR, Local Partners
Increase use of reduced tillage practices in watershed	Number of acres cropland with conservation practice applied	Up to 2,648 acres	$49,360	Up to 3,333 lbs	EQIP, TRM, SWG	NRCS, Walworth County, WDNR, Local Partners
Increase use of cover crops	Number of acres cropland with conservation practice applied	Up to 2,648 acres	$148,450	Up to 3,336 lbs	EQIP, TRM, SWG	NRCS, Walworth County, WDNR, Local Partners
Ensure that nutrient management plans are implemented on all farmed lands	Number of acres cropland with conservation practice applied	Up to 2,648 acres	$105,920	Up to 3,217 lbs	EQIP, TRM, SWG	NRCS, Walworth County, WDNR, Local Partners
Install additional grassed waterways[e]	Number of linear feet of grassed waterways installed	Up to 53,800 feet	$269,000	Up to 2,262 lbs	EQIP, TRM, SWG	NRCS, Walworth County, WDNR, Local Partners
Implement regenerative stormwater conveyance practices to reduce head cutting and bank erosion	Number of linear feet of stream channel with projects installed	As required	Varies by practice	Varies	TRM, SWG	NRCS, WDNR, Walworth County, Local Partners
Consider alum treatment if conditions severely deteriorate	Number of acres to which alum applied	Up to entire lake	Up to $3,780,000	Immobilizes phosphorus	SWG	WDNR, Local Partners

a Estimated per unit costs are as follows: 20.00 for reduced tillage, 60.15 per acre for cover crops, 40.00 per acre for nutrient management plans, 5.00 per linear foot for grassed waterways, 440 per acre for riparian buffer, 4,000 per acre for land conversion, and between 280 and 700 per acre for alum treatment.

b Estimated phosphorus reductions per acre were sourced from the STEPL pollutant loading model for each conservation practice individually applied to one acre of cultivated cropland.

c See Section 3.12, "Plan Implementation" for a description of the Environmental Quality Incentives Program (EQIP), Total Runoff Management (TRM), Conservation Reserve Enhancement

Program (CREP), Conservation Reserve Program (CRP), the Surface Water Grants (SWG), and the Urban Nonpoint Source & Storm Water Management Grant (UNPS&SW) programs.

*d The estimated costs provided are based on an approximation of the accessible Bigfoot Creek wetland area and the typical cost to remove invasive hybrid cattail (*Typha x glauca*) and plant native vegetation in heavily saturated areas. However, estimating the costs for a project of this scale are beyond the scope of this lake management plan. A detailed site management plan would be required to complete this project; this site plan would provide more accurate estimates of the project cost than this lake plan can provide.*

e For phosphorus and sediment load reduction estimates, Commission staff assumed gully dimensions of 1 foot depth and 1 foot width. Actual load reductions will likely vary based on specific conditions of each gully.

Source: Walworth County, NRCS, WDNR, Minnesota Pollutant Control Agency, and SEWRPC

Table 3.3
Example WDNR Grant Programs Supporting Lake and River Management Activities

Category	Program	Grant Program	Maximum Grant Award	Minimum Grantee Match (percent)	Application Due Date[a]
Water	Surface Water Grants	Aquatic Invasive Species (AIS) Prevention and Control	Clean Boats, Clean Waters: $24,000	25	November 15
			Large-Scale Population Control: $150,000 Small-Scale Population Control: $50,000	25	November 15
			Early Detection and Response: $25,000	25	Year-Round
			Prevention: $24,000	25	November 15
			Research and Demonstration annual limit: $500,000	25	November 15
			Lake Monitoring and Protection Network: Varies[b]	Varies	November 15
		Surface Water Education	$5,000 per project $50,000 per waterbody	33	November 15
		Surface Water Plan	Lakes and Rivers: $10,000	33	November 15
			Aquatic Invasive Species (AIS): $10,000	33	November 15
		Comprehensive Management Plan	$25,000	33	November 15
		County Lake Grant	$50,000	33	November 15
		Ordinance Development	$50,000	25	November 15
		Management Plan Implementation	Lakes: $200,000 Rivers: $50,000	25	November 15
		Healthy Lakes & Rivers	$1,000 per practice $25,000 per waterbody	25	Year-Round
		Surface Water Restoration	Lakes: $50,000 Rivers: $25,000	25	November 15
		Land Acquisition and Easement	Lakes: $200,000 Rivers: $50,000	25	November 15
	Targeted Runoff Management	--	Small-Scale: $225,000	30	April 15
			Large-Scale: $600,000	30	April 15
	Urban Nonpoint Source & Stormwater Management	--	Planning: $85,000 Property Acquisition: $50,000 Construction: $150,000	50	April 15
Conservation and Wildlife	Knowles-Nelson Stewardship Program	Habitat Areas	--	50	March 1, August 1, and November 1
		Natural Areas	--	50	March 1, August 1, and November 1
		Streambank Protection	--	50	March 1, August 1, and November 1
		State Trails	--	50	March 1, August 1, and November 1

Category	Program	Grant Program	Maximum Grant Award	Minimum Grantee Match (percent)	Application Due Date[a]
Boating	Boat Enforcement Patrol	--	Up to 75% reimbursement	None	Various
	Boating Infrastructure Grant	--	Up to $300,000 per state	25	June 1
Recreation	Knowles-Nelson Stewardship Program	Acquisition and Development of Local Parks	--	50	May 1
		Acquisition of Development Rights	--	50	May 1
		Urban Green Space	--	50	May 1
		Urban Rivers	--	50	May 1
	Sport Fish Restoration	Boat Access	Varies annually	25	February 1
		Fishing Pier	Varies annually	25	October 1

Table continued on next page.

Note: This table incorporates information from NR 193, which was made effective on June 1st, 2020. More information regarding these example grant programs may be found online at the following address: https://dnr.wisconsin.gov/aid/Grants.html. Additional federal, state, and local grant opportunities are available. Eligibility varies for each grant program.

[a]Application due dates represent the last day to submit a finalized grant application. Other deadlines for pre-applications or pre-proposals may be needed prior to the application due date under specific grant categorys. Check with the appropriate WDNR contact to ensure timeline of needed materials.

[b]Annual funding is allocated to each Wisconsin County based on a statistical model with variables that include resource quantity and condition, network condition, people, and economy.

Source: Wisconsin Department of Natural Resources and SEWRPC

Table 3.4
Lake Management Roles and Authority

Authority/Activities	GLEA, Land Trusts, Lake Associations, or HOAs	Lake District	Municipality	County	WDNR
Levy taxes on property owners for lake management	--	X	X	--	--
Establish boating ordinance	--	(only if delegated by municipalities)	X (through joint municipal ordinance)	--	--
Enforce boating ordinance	--	(only if delegated by municipalities)	X (through Geneva Lake Law Enforcement Agency)	--	--
Pier and buoy permitting	(must apply for permits to do activities)	--	X	--	X
Own and regulate public boat launches	--	(only if acquired from and power delegated by municipalities)	X	--	X (establishes rules on maximum fee amounts and minimum public access per lake acreage to be eligible for grants)
Erosion control and stormwater management permitting	--	--	X	X	--
Land use and zoning (including shoreland zoning)	--	--	X	X	X
Develop studies and monitor lake	X	X	X	X	X
Conduct in-lake management activities, e.g. aquatic plant harvesting, improve fish habitat, etc.	X (may require WDNR permit)	X (may require WDNR permit)	X (may require WDNR permit)	--	X
Promote and fund watershed best management practices, e.g., riparian buffers, rain gardens, cover crops, preserving sensitive areas, etc.	X	X	X	X	X

Source: SEWRPC

Table 3.5
Abilities of Governmental Organizations Involved in Lake Management

Features	Intergovernmental Commissions	Sanitary District [a]	Water Commission	Lake District
Government unit	X	X	X	X
Taxing authority	--	X	X [b]	X
Enact boating regulations using joint agreements	--	--	X	X
Eligible for lake state grants	X	X	X	X
Borrow money	X	X	X	X
Make contracts	X	X	X	X
Acquire and sell property	X	X	X	X
Sue and be sued	X	X	X	X
Sponsor boat patrols	--	X	X	X
Governed by	Local elected officials	District commissioners; resident requirement to hold office	Local elected or appointed officials	District elections; locals and nonresidents can hold office
Meeting requirements	Yes	Quarterly	Quarterly	Quarterly; annual meeting during summer

[a] Sanitary Districts have additional septic and waste responsibilities.

[b] Water commissions can be granted taxing authority by the State legislature upon their creation, however, neither existing commission has the authority to directly levy a tax. The Dane County Lakes and Watershed Commission can petition the Dane County board to levy a tax The Southeastern Wisconsin Fox River Commission does not have this option.

Source: Geneva Lake Environmental Agency and SEWRPC

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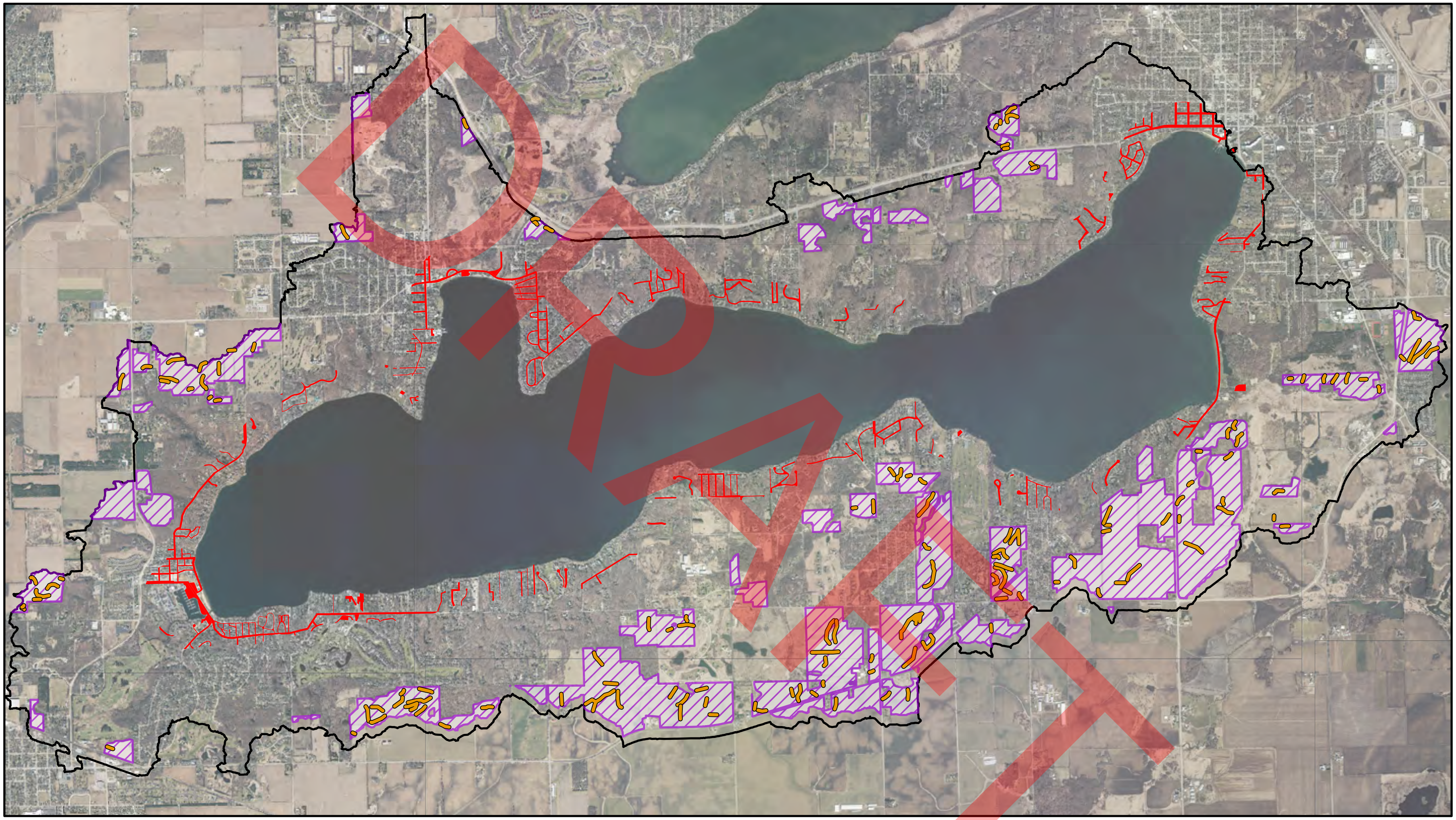
WALWORTH COUNTY, WISCONSIN

Chapter 3 Figures

Figure 3.1
Pollutant Loading Recommendations for Geneva Lake



Priority Roads to Decrease Road Salts/De-Icers

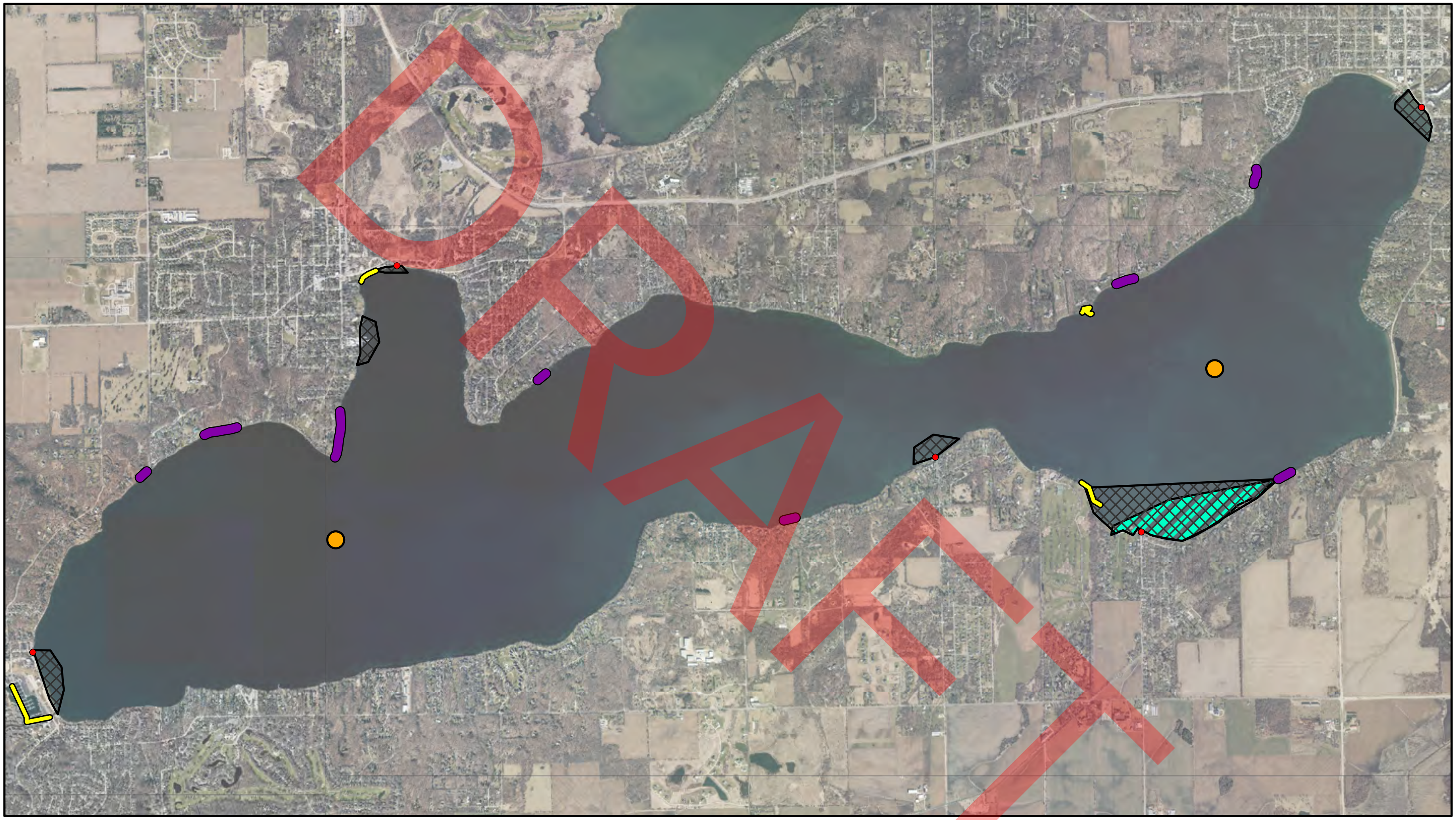
Potential Grassed Waterways

Sites to Implement Agricultural BMPs

Geneva Lake Watershed

Source: SEWRPC

Figure 3.2
Water Quality and Monitoring Recommendations for Geneva Lake



AIS Decontamination Sites

Protection of Nearshore Fisheries

Establish Fisheries Habitat

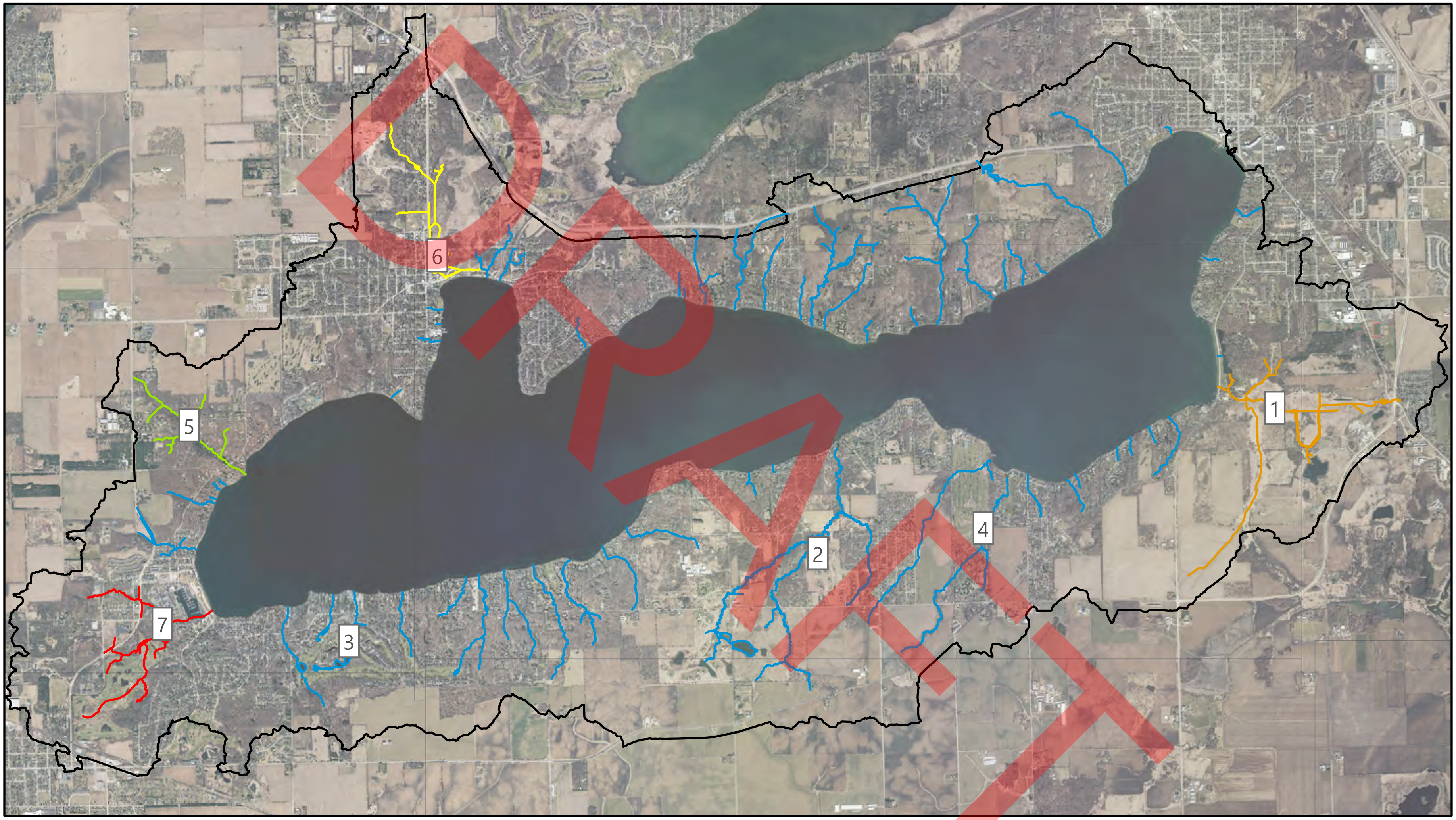
Sites for Increased Surveys (AIS meander, sub-PIs)

Starry Stonewort Warning Zone

Water Quality Testing

Source: SEWRPC

Figure 3.3
Tributary Recommendations for Geneva Lake



1 Tributary Projects by Priority

Geneva Lake Watershed

Project Type

- Implement recommended projects from previous studies
- Wetland restoration
- Naturalize stream course
- Regenerative stormwater conveyance, implementation of agricultural BMPs in headwaters, saturated buffers in agricultural lands
- Regenerative stormwater conveyance and/or retention ponds, disconnect drainage tile and/or enhance stormwater detention in headwaters

Source: SEWRPC

Figure 3.4
Grassed Waterways in the Geneva Lake Watershed

Source: SEWRPC

Figure 3.5
Invasive Buckthorn and Honeysuckle Species

Common buckthorn (Rhamnus cathartica)

Glossy Buckthorn (Rhamnus frangula)

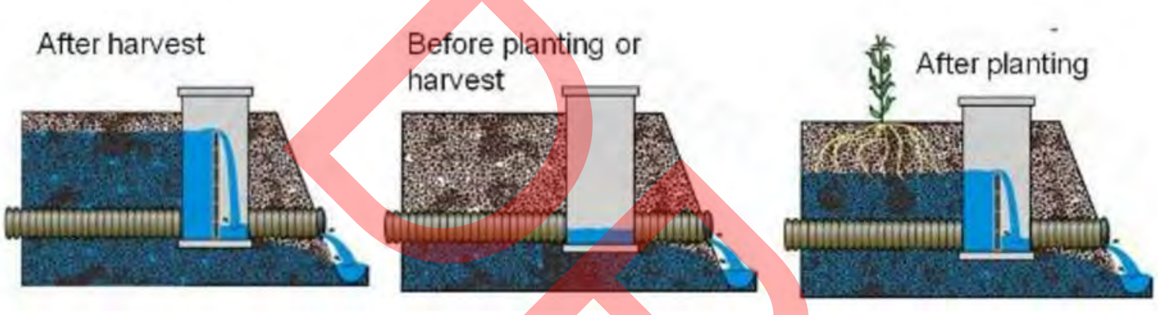
Japanese honeysuckle (Lonicera japonica)

Tatarian honeysuckle (Lonicera tatarica)

Morrow's honeysuckle (Lonicera morrowii)

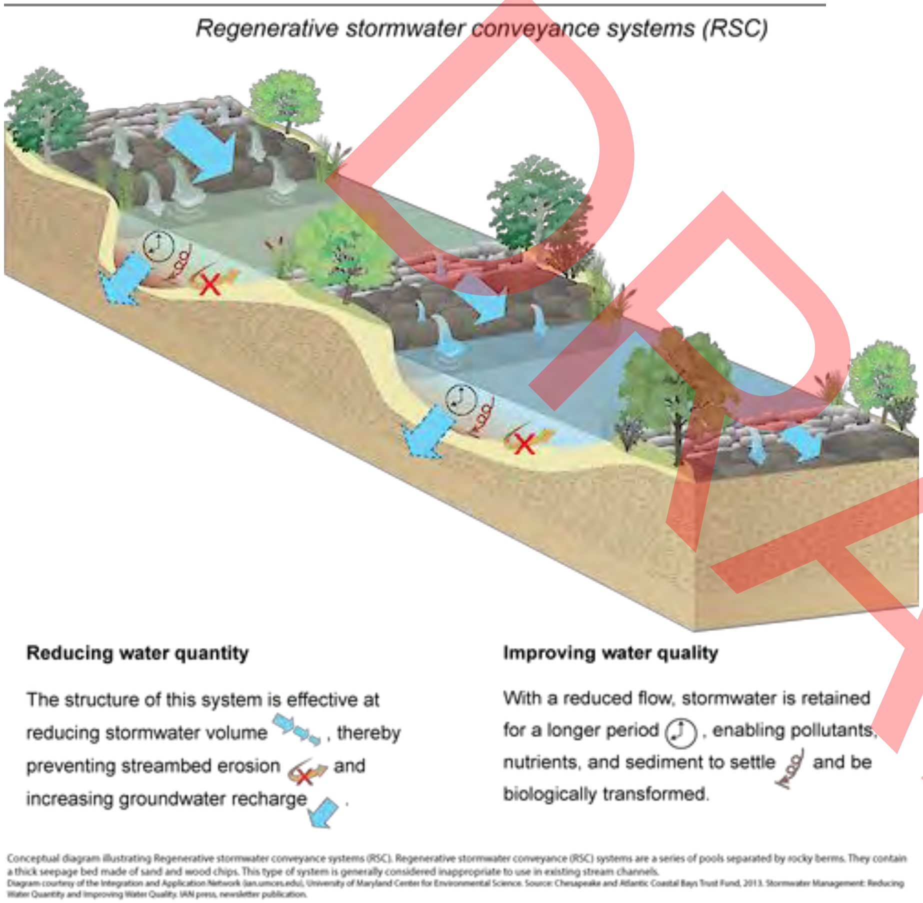
Source: WDNR

Figure 3.6
Inline Water Control Diagram



Source: Purdue University

Figure 3.7
Regenerative Stormwater Conveyance

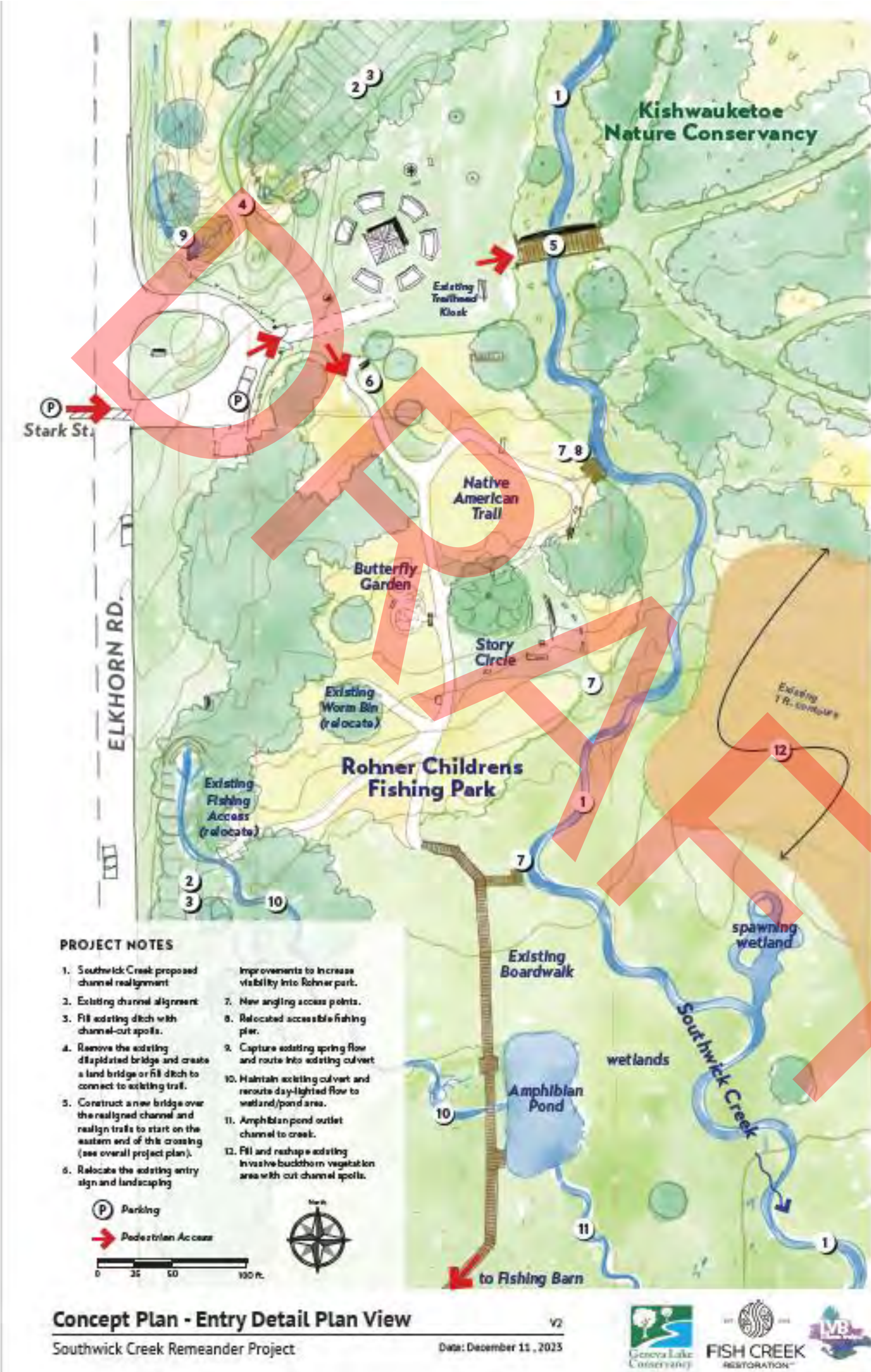


Source: Jane Hawkey, Integration and Application Network

Figure 3.8
Regenerative Stormwater Conveyance Along Hwy 67

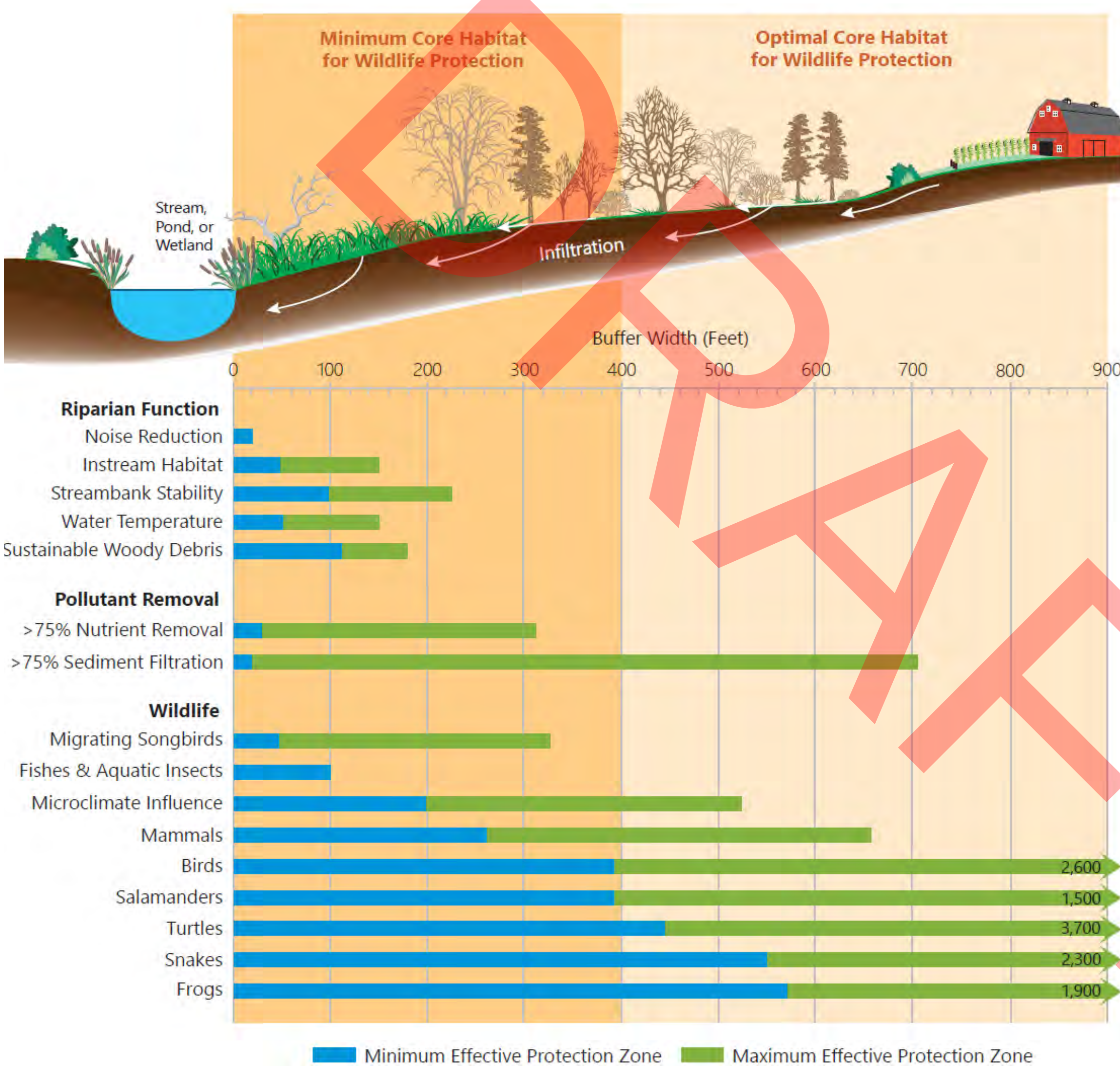
Source: Google

Figure 3.9
Southwick Creek Remeander Project



Source: SEWRPC

Figure 3.10
Shoreline Buffer Benefits



Source: SEWRPC

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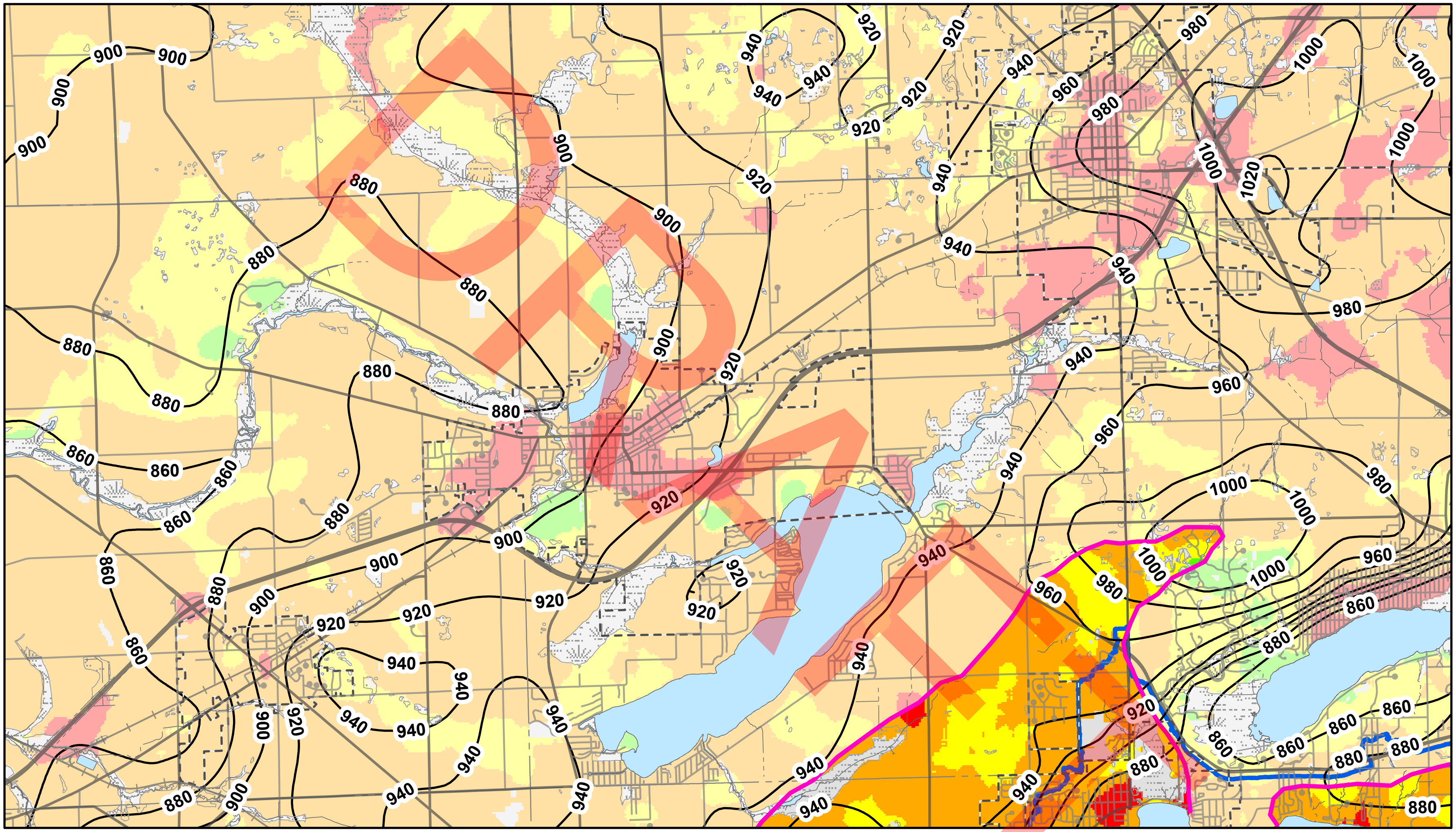
Appendix A

Appendix A.1
Groundwater Elevation Contours and Recharge Potential Within and Beyond the Geneva Lake Watershed: NE Quadrant



WATER RECHARGE POTENTIAL

- VERY HIGH
- HIGH
- MODERATE
- LOW
- UNDETERMINED

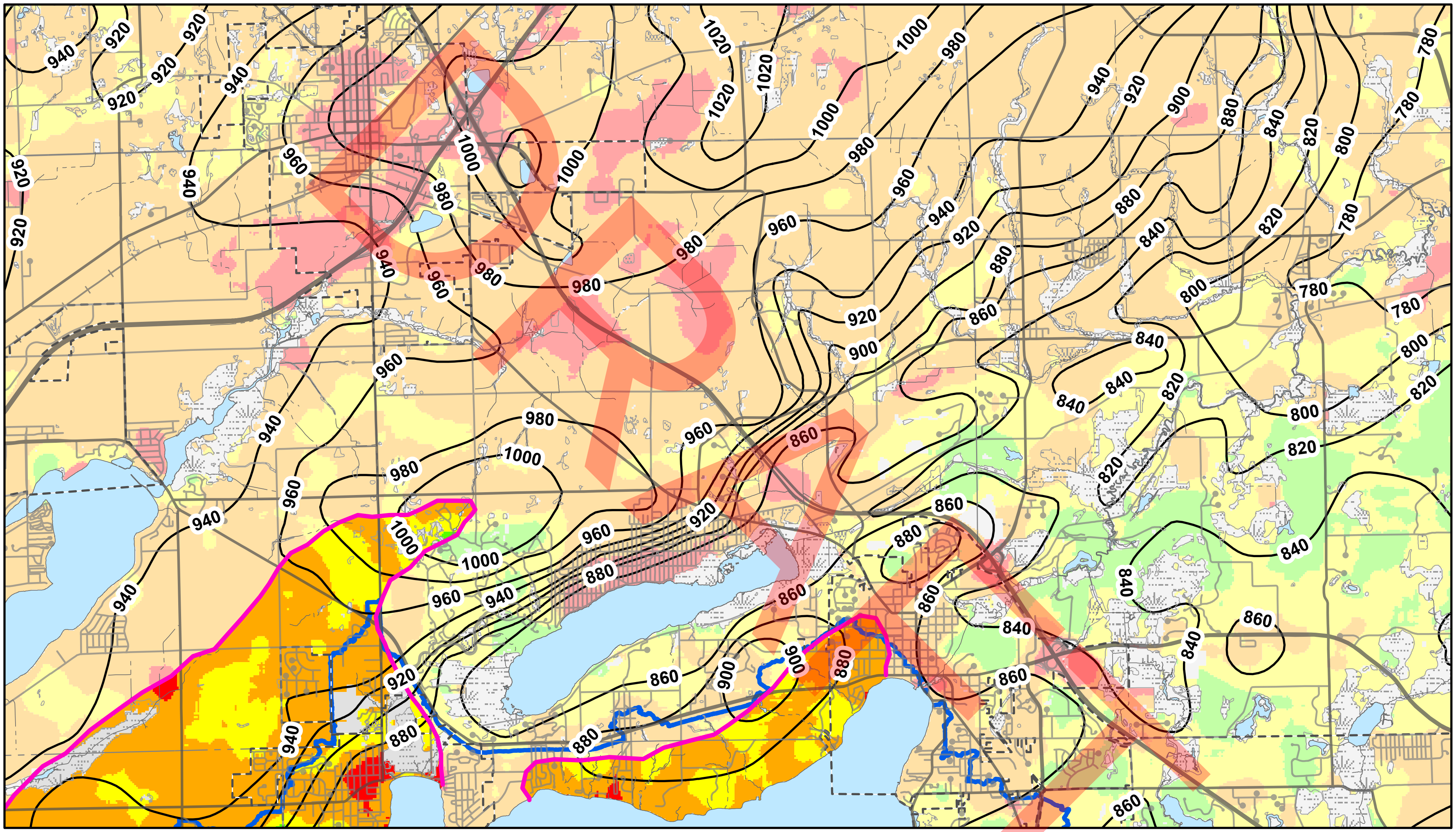
- WATER TABLE ELEVATION CONTOUR
- 950 WATER TABLE ELEVATION
- GENEVA LAKE WATERSHED
- GENEVA LAKE GROUNDWATERSHED
- SURFACE WATER

Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

0 1 2 3 Miles

Source: Wisconsin Geological and Natural History Survey and SEWRPC

Appendix A.2
Groundwater Elevation Contours and Recharge Potential Within and Beyond the Geneva Lake Watershed: NW Quadrant



WATER RECHARGE POTENTIAL

- VERY HIGH
- HIGH
- MODERATE
- LOW
- UNDETERMINED

- WATER TABLE ELEVATION CONTOUR
- 950 WATER TABLE ELEVATION
- GENEVA LAKE WATERSHED
- GENEVA LAKE GROUNDWATERSHED
- SURFACE WATER

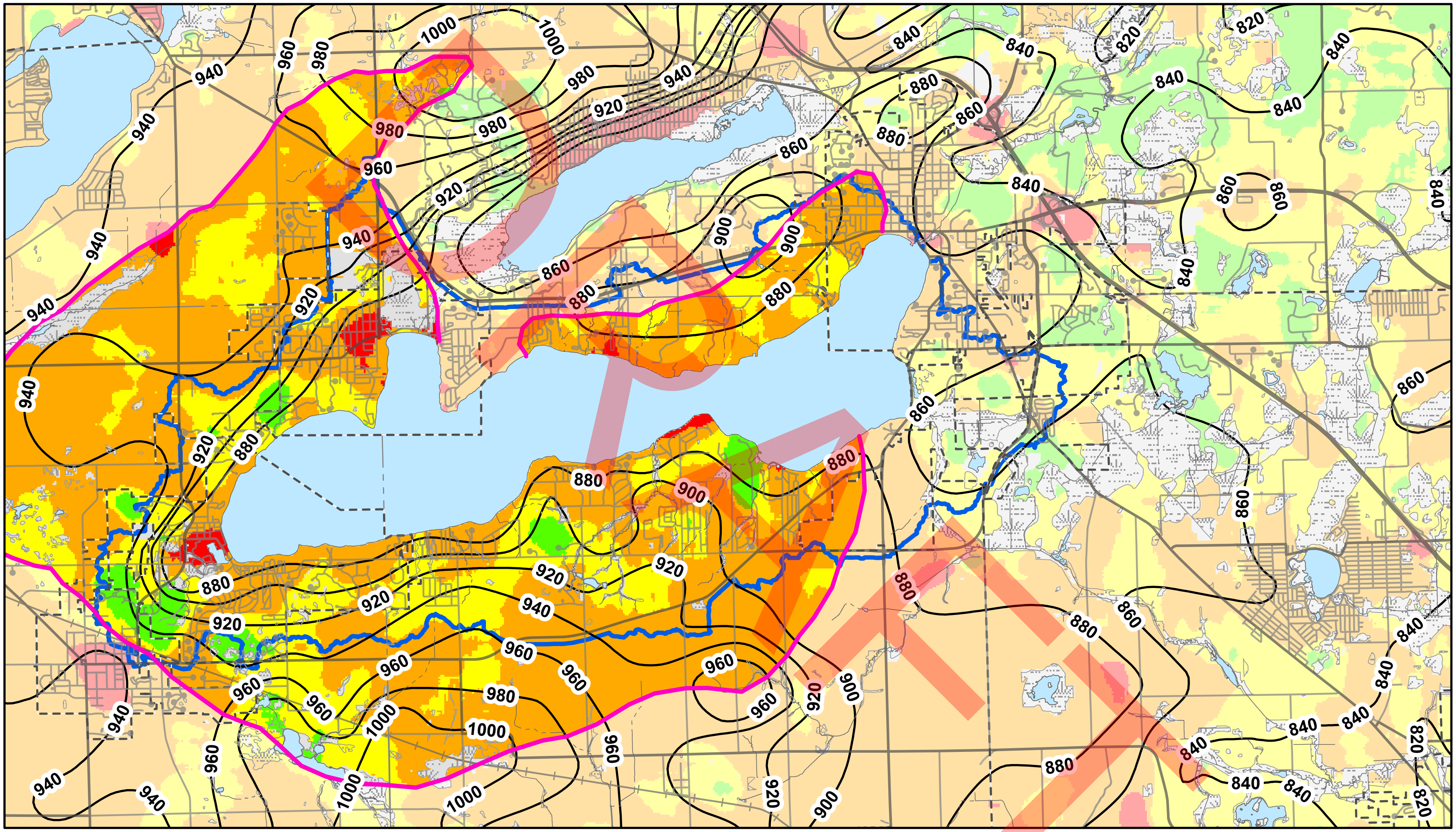
Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

N

0 1 2 3 Miles

Source: Wisconsin Geological and Natural History Survey and SEWRPC

Appendix A.3
Groundwater Elevation Contours and Recharge Potential Within and Beyond the Geneva Lake Watershed: SE Quadrant



WATER RECHARGE POTENTIAL

- VERY HIGH
- HIGH
- MODERATE
- LOW
- UNDETERMINED

- WATER TABLE ELEVATION CONTOUR
- 950 WATER TABLE ELEVATION
- GENEVA LAKE WATERSHED
- GENEVA LAKE GROUNDWATERSHED
- SURFACE WATER

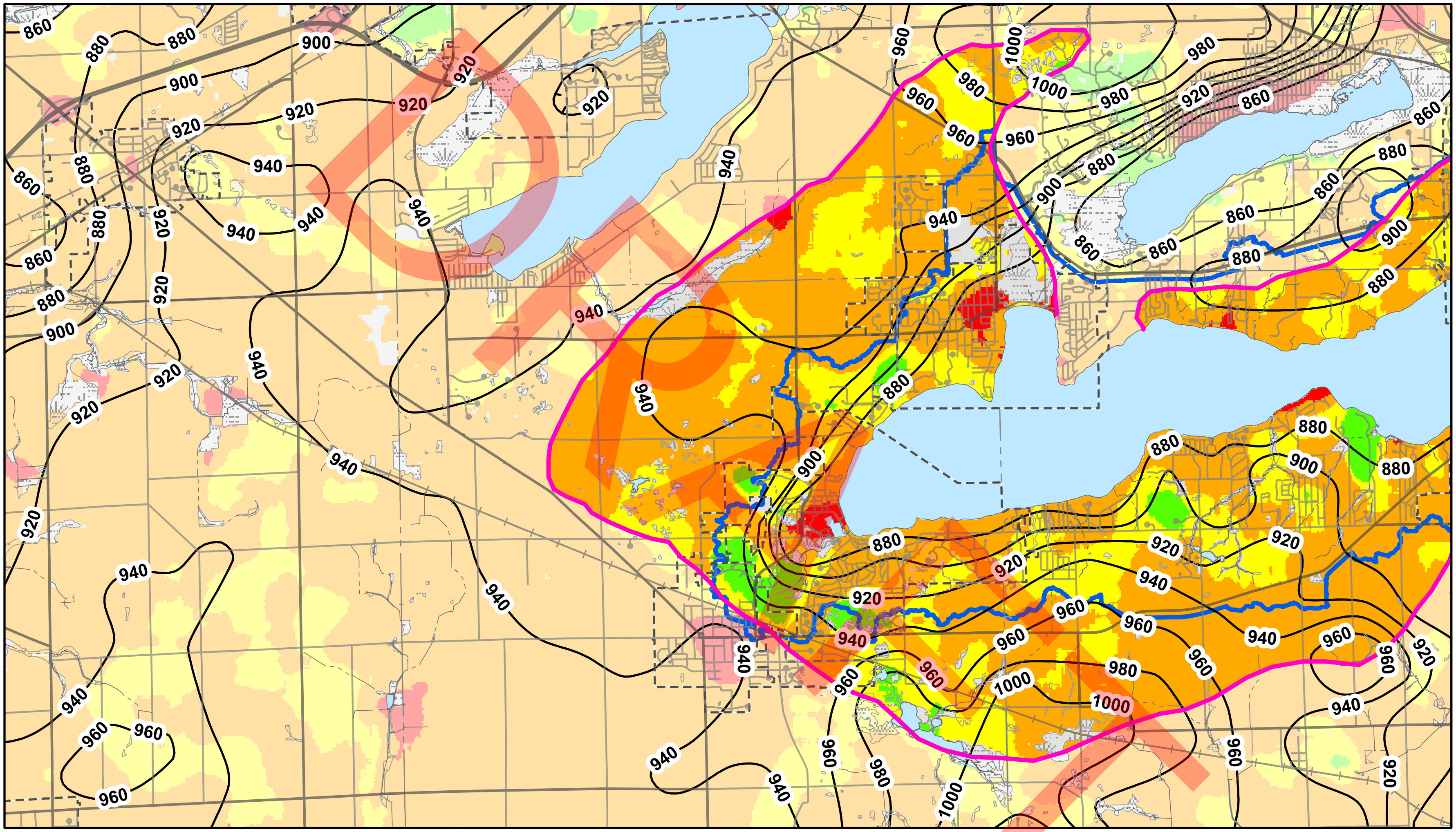
Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

N

0 1 2 3 Miles

Source: Wisconsin Geological and Natural History Survey and SEWRPC

Appendix A.4
Groundwater Elevation Contours and Recharge Potential Within and Beyond the Geneva Lake Watershed: SW Quadrant



WATER RECHARGE POTENTIAL

- VERY HIGH
- HIGH
- MODERATE
- LOW
- UNDETERMINED

- WATER TABLE ELEVATION CONTOUR
- **950** WATER TABLE ELEVATION
- GENEVA LAKE WATERSHED
- GENEVA LAKE GROUNDWATERSHED
- SURFACE WATER

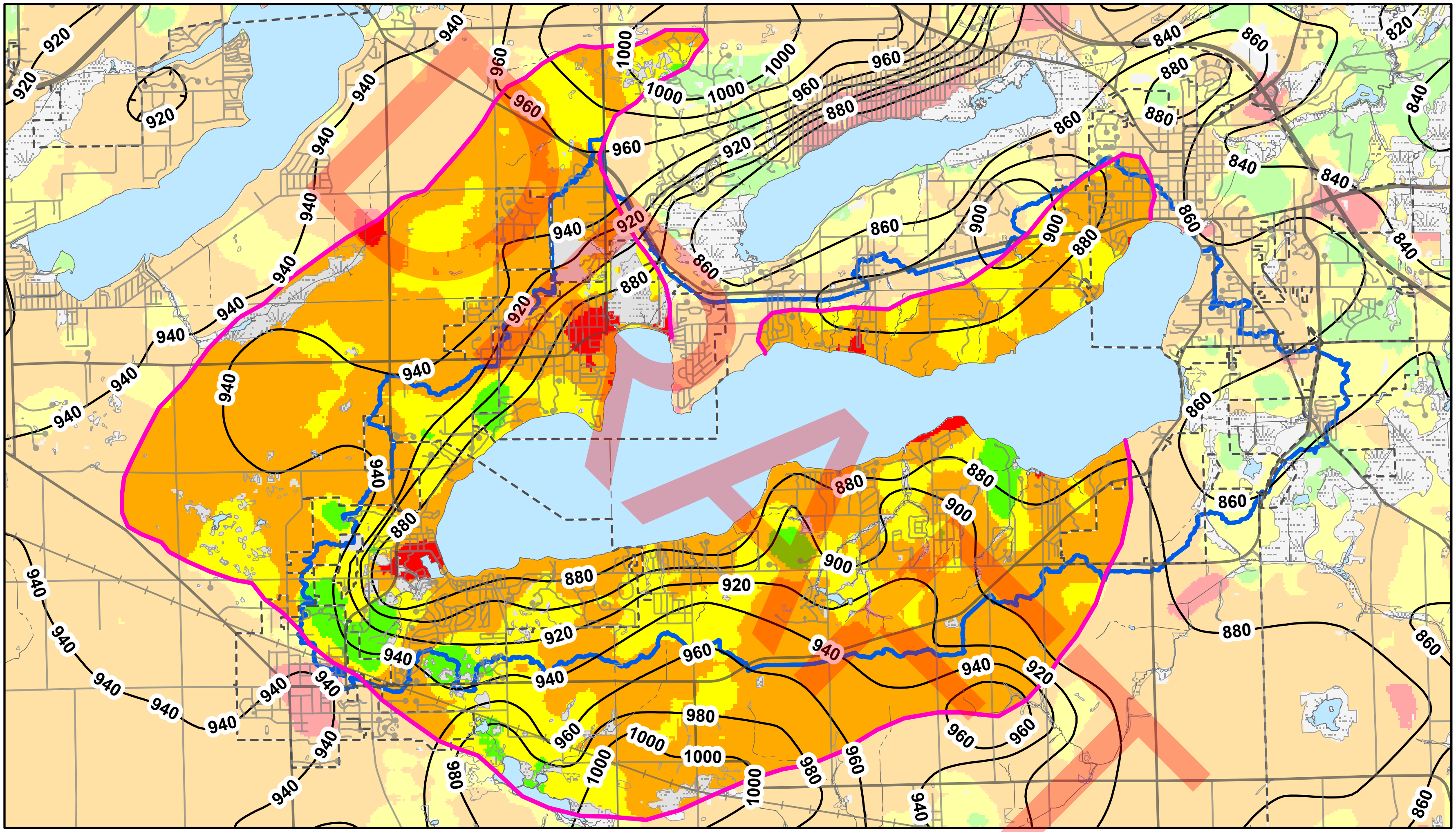
Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

N

0 1 2 3 Miles

Source: Wisconsin Geological and Natural History Survey and SEWRPC

Appendix A.5
Groundwater Elevation Contours and Recharge Potential Within the Geneva Lake Groundwatershed



WATER RECHARGE POTENTIAL

- VERY HIGH
- HIGH
- MODERATE
- LOW
- UNDETERMINED

- WATER TABLE ELEVATION CONTOUR
- 950 WATER TABLE ELEVATION
- GENEVA LAKE WATERSHED
- GENEVA LAKE GROUNDWATERSHED
- SURFACE WATER

Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

0 1 2 3 Miles

Source: Wisconsin Geological and Natural History Survey and SEWRPC

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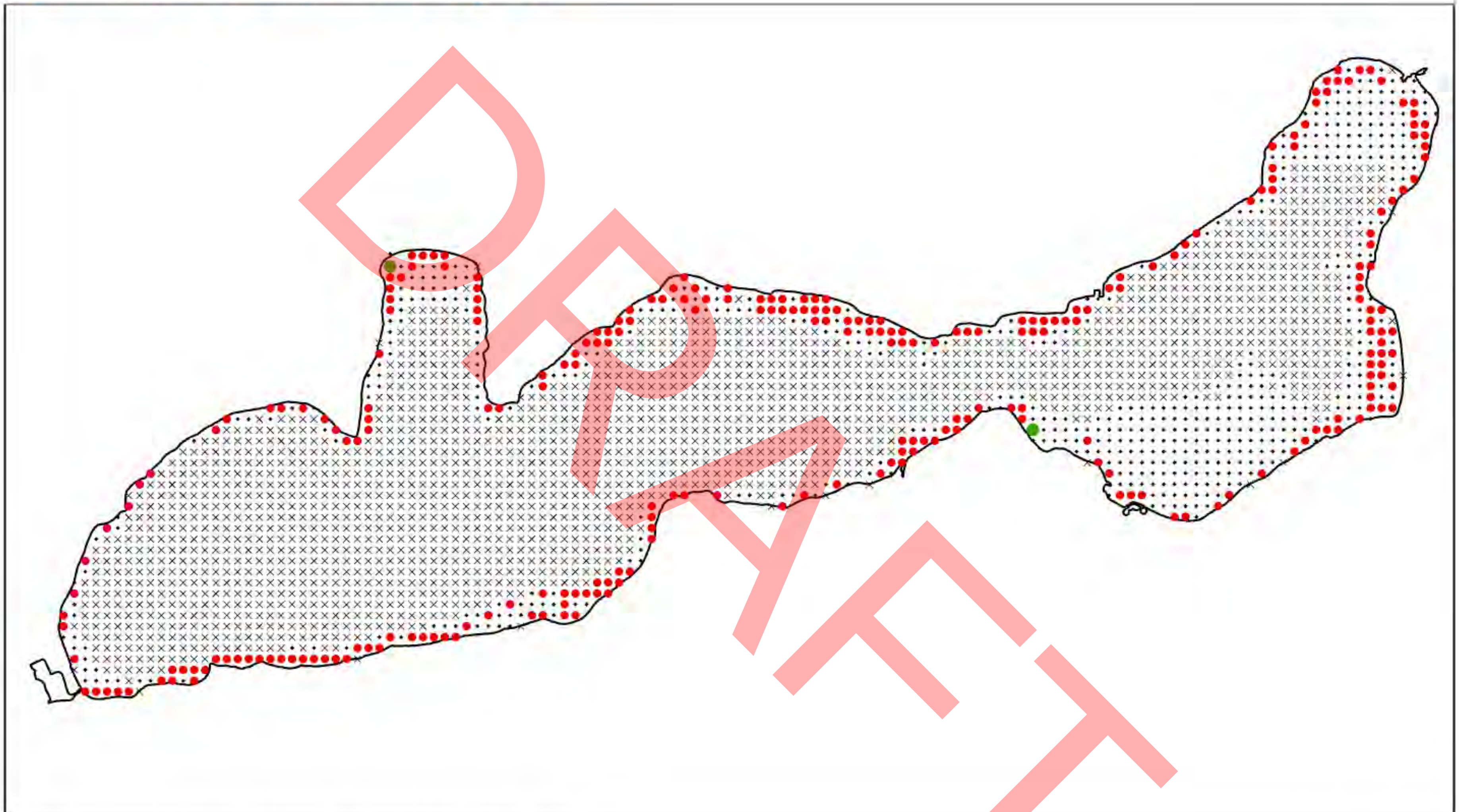
WALWORTH COUNTY, WISCONSIN

Appendix B

Figure.Eelgrass Total Rake Fullness in Geneva Lake: July 2024
Eelgrass Total Rake Fullness in Geneva Lake: July 2024



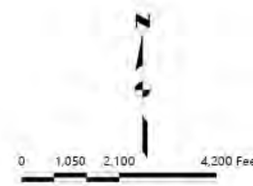
NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.

RAKE FULLNESS RATING

1 2 3

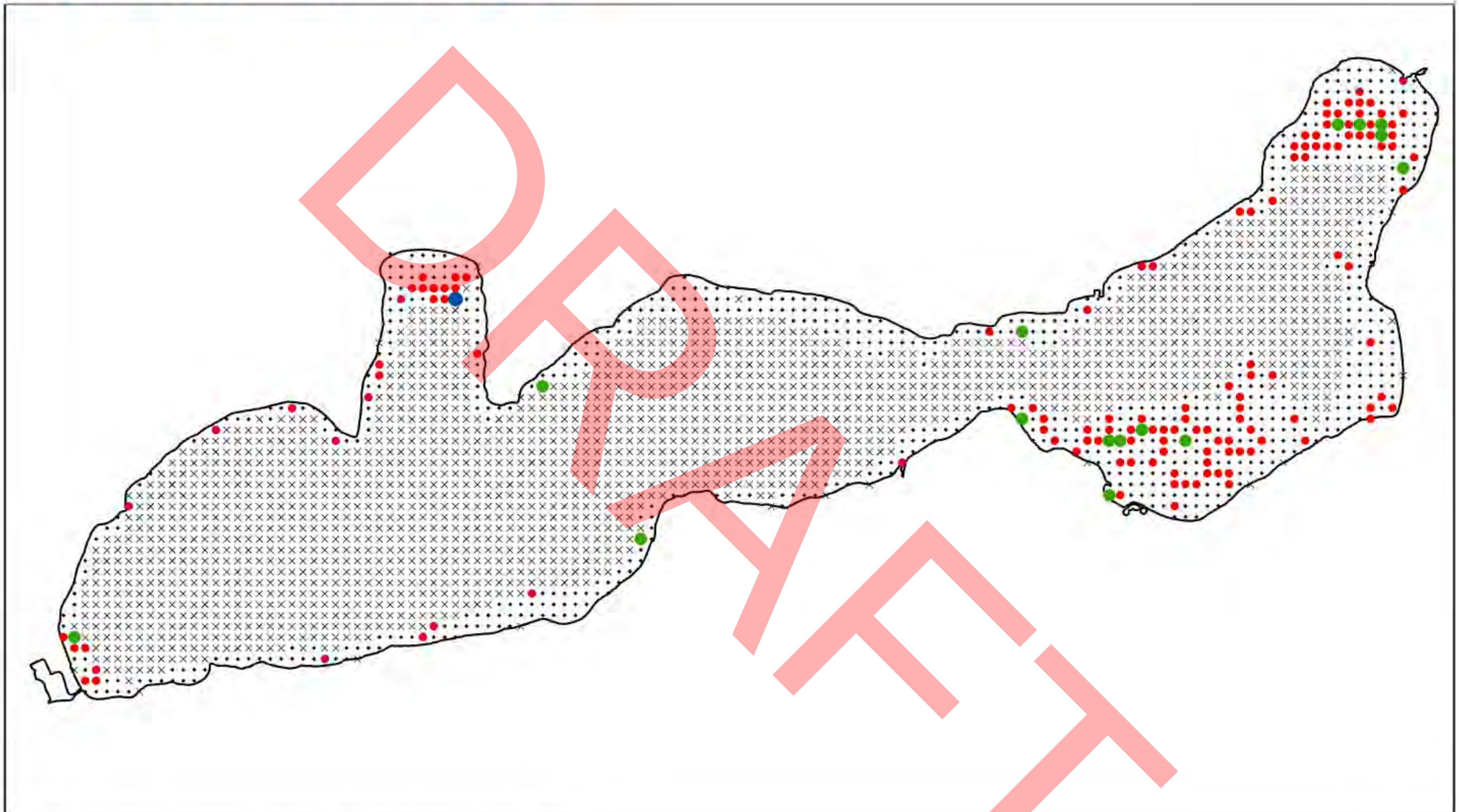
VISIBLE NEARBY

• NO AQUATIC PLANTS FOUND × NOT SAMPLED



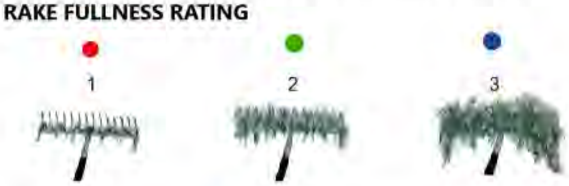
Source: WDNR and SEWRPC

Figure.Muskgrass Total Rake Fullness in Geneva Lake: July 2024
Muskgrass Total Rake Fullness in Geneva Lake: July 2024



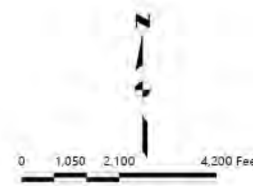
NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.

RAKE FULLNESS RATING



VISIBLE NEARBY

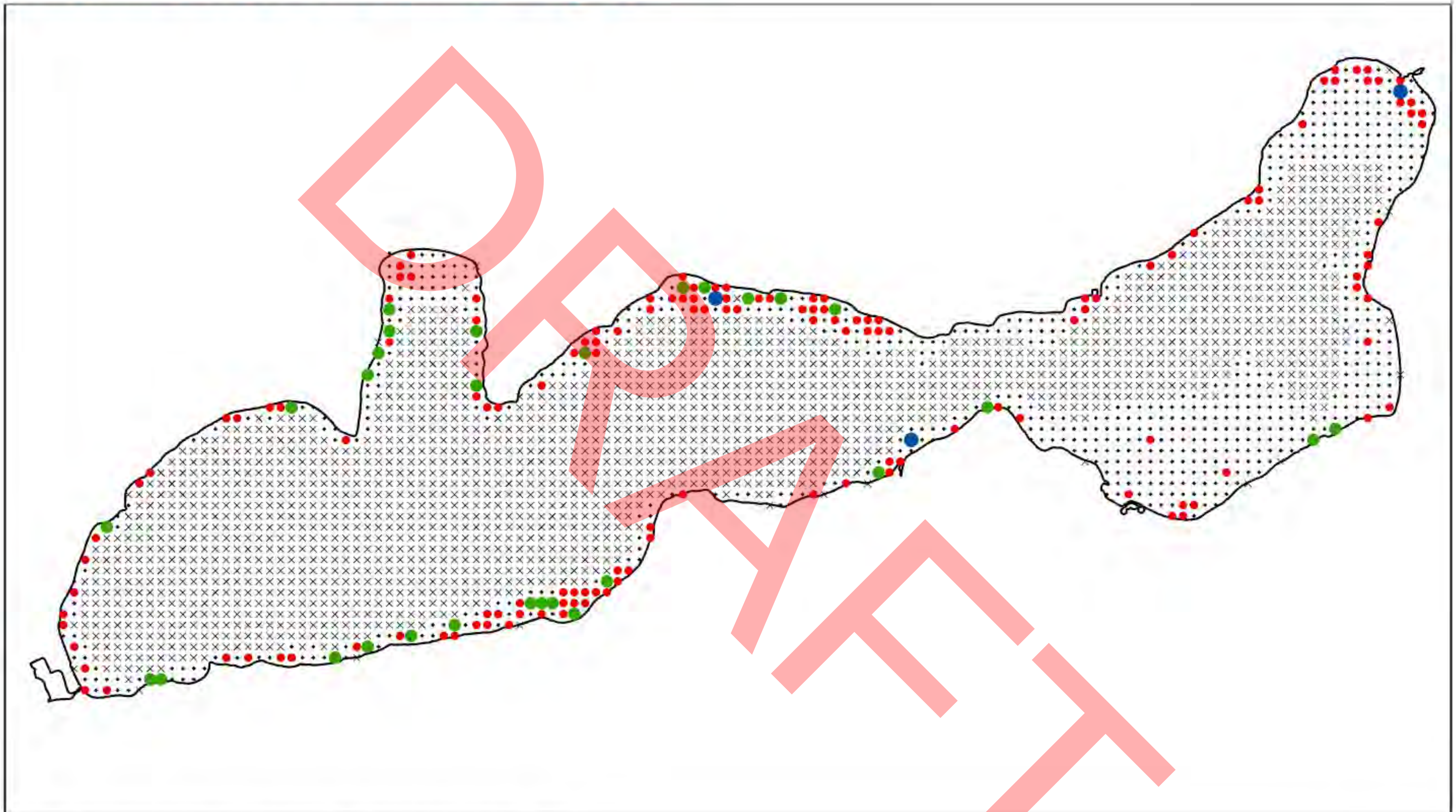
NO AQUATIC PLANTS FOUND × NOT SAMPLED



Source: WDNR and SEWRPC

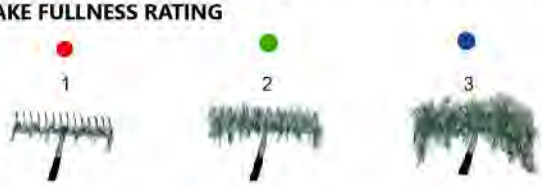
Figure.Forked Duckweed Total Rake Fullness in Geneva Lake: July 2024

Forked Duckweed Total Rake Fullness in Geneva Lake: July 2024



NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.

RAKE FULLNESS RATING



VISIBLE NEARBY

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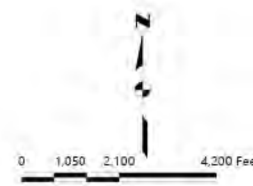

Source: WDNR and SEWRPC

Figure.Forked Duckweed Total Rake Fullness in Geneva Lake: July 2024
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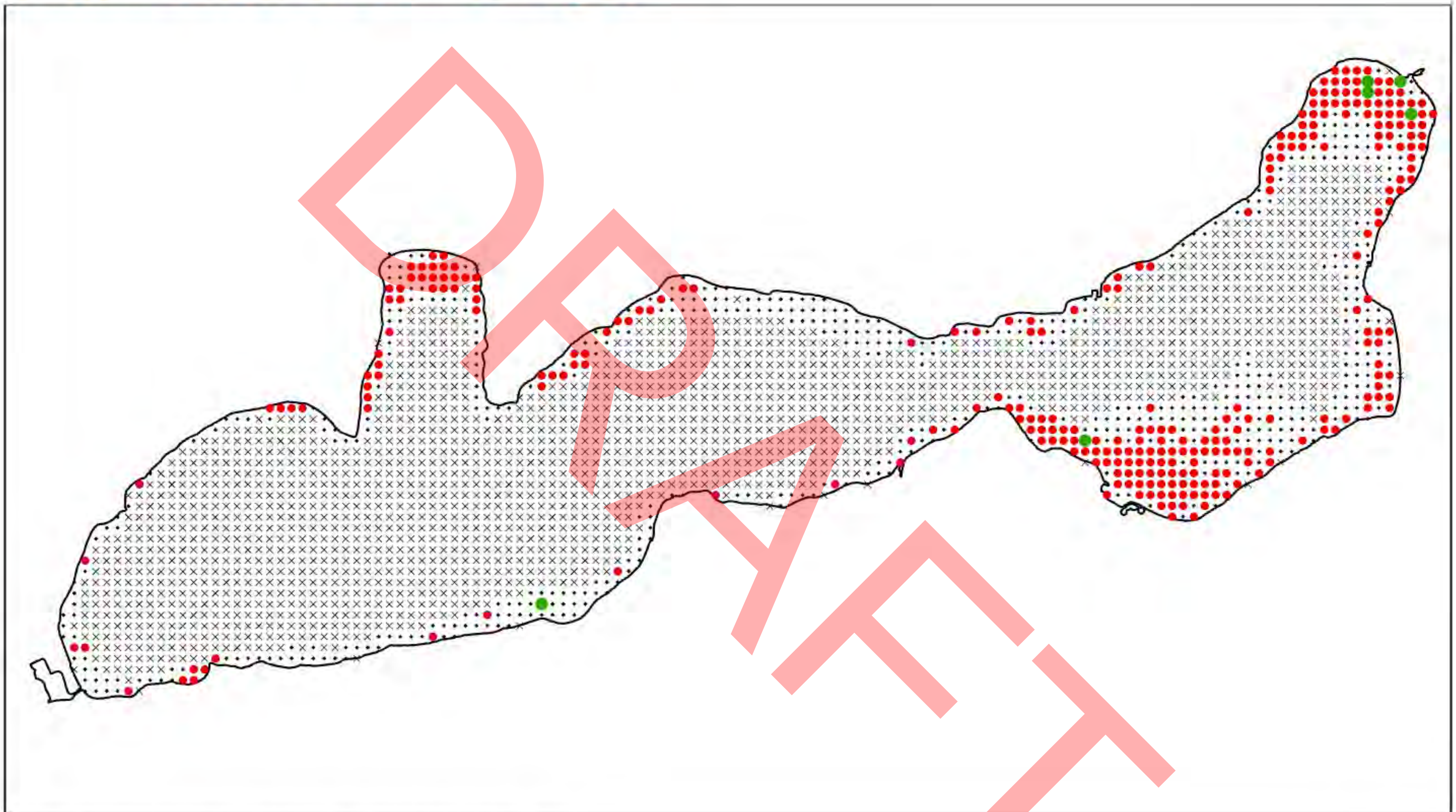
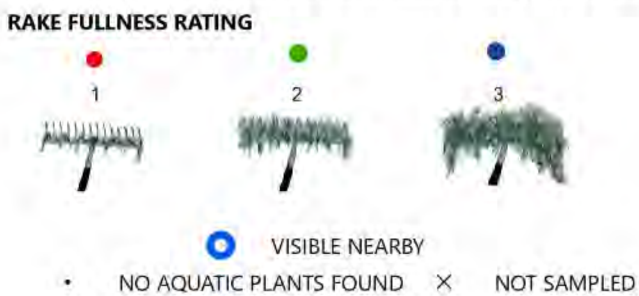
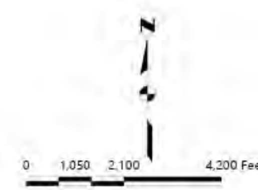


NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.





Source: WDNR and SEWRPC

Figure.Muskgrass Total Rake Fullness in Geneva Lake: July 2024
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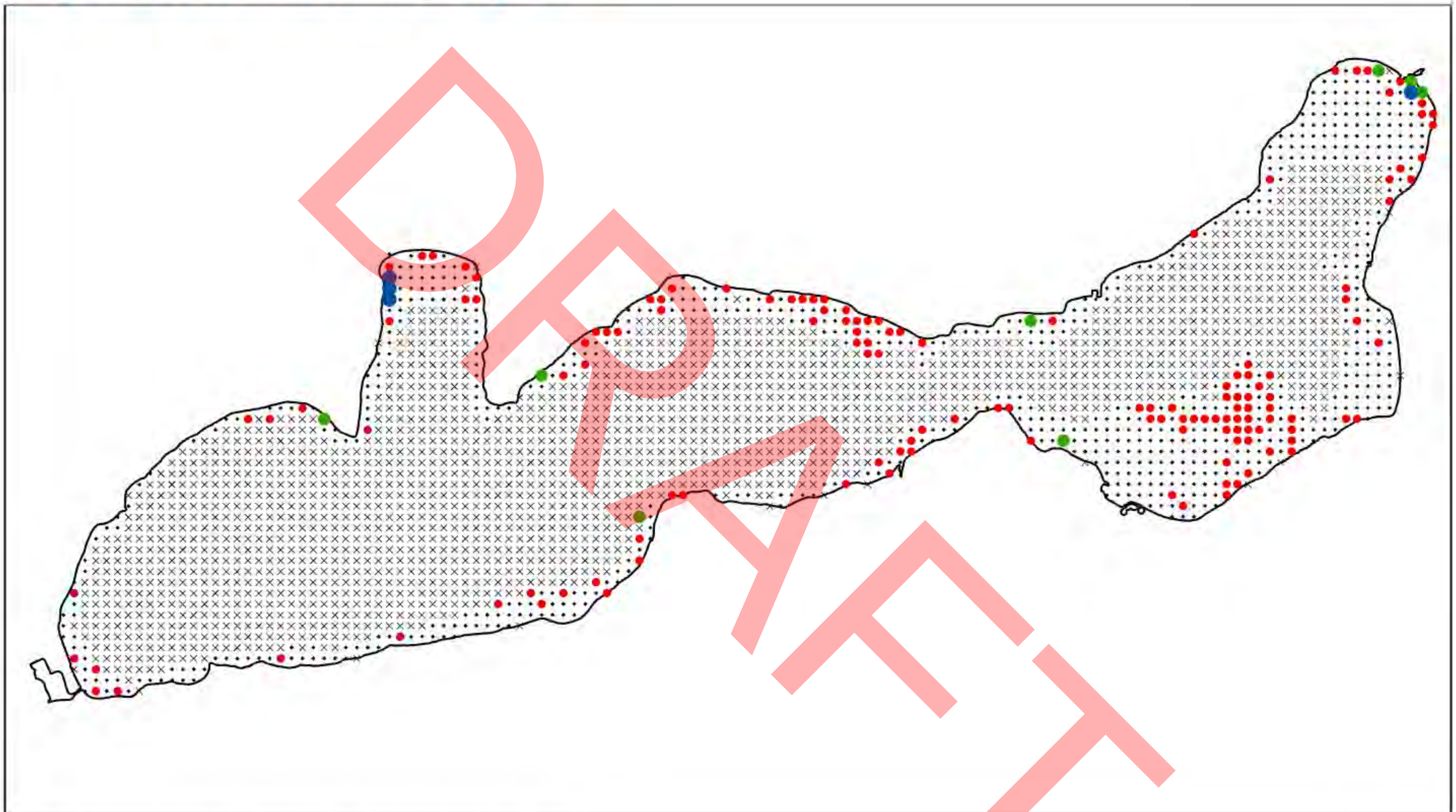
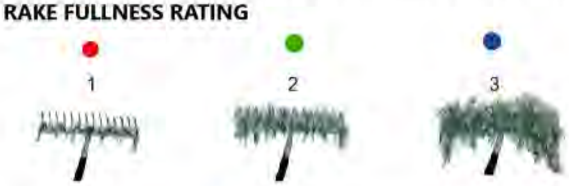


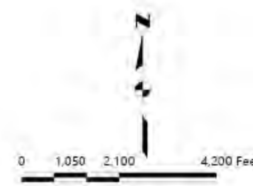
NOTE: Survey was conducted on Geneva Lake from July 22nd-25th, 2024.

RAKE FULLNESS RATING



VISIBLE NEARBY

• NO AQUATIC PLANTS FOUND × NOT SAMPLED



Source: WDNR and SEWRPC